We propose a non-disruptive target of opportunity proposal to observe the aftermath of giant impact events or storm plumes on Jupiter and Saturn. Although such events are likely to occur within the foreseen lifetime of JWST, they remain impossible to predict in advance. JWST could provide spectroscopic maps of reflected sunlight (NIRSPEC) and thermal emission (MIRI), allowing us to derive the 3D structure of temperatures, winds, chemical composition and aerosols associated with these unique and rare events. For planetary impacts, the distribution of energy and chemicals (like ammonia) from the impact can reveal the impactor direction, penetration, and tensile strength; the reducing or oxidising chemistry can reveal the water content of the impactor; and the silicate debris can reveal its origins and chemical make-up. For giant planet storms, the thermal structure can reveal the energy released by the storm and the vigour of the rising motions; while the presence of unusual chemicals and aerosols can reveal the processes shaping jovian meteorology and provide a unique window onto the chemistry of the deeper, sub-cloud regions. The ToO will specifically target spectroscopy that cannot be reliably obtained from Earth, and will be supported by ground-based observations tracking the evolving impact/storm morphology. Only large impacts with early signs of debris, or significant and rare storms (particularly on Saturn), will be considered for this JWST trigger.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01433
Program Title: Physical Properties of the Triply-Lensed $z = 11$ Galaxy
Principal Investigator: Dan Coe
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The $z = 11.1$ galaxy MACS0647-JD is one of the two most distant objects known. It is strongly lensed by a foreground cluster to form three images, with AB mag = 25.9, 26.1, and 27.3, which enables a detailed study with JWST. This provides us with a unique opportunity to begin to study the early phases of galaxy formation at the cosmic age of only 400 Myr, aided by nature’s own cosmic lens. Despite the magnification, the system is spatially unresolved with HST, which means its radius must be < 100 pc, the size of Giant Molecular Clouds. Packed into that small radius is a significant stellar mass (1e7 – 1e9 Msun) that is producing new stars at a rate of a few Msun / yr. Our proposed NIRCam and NIRSpec observations will allow us to obtain significant new insights into the nature of this young galaxy that are beyond the reach of current facilities, including:

1) A precise spectroscopic redshift from one or more lines
2) More precise measurements of the SFR, stellar mass, age, and dust extinction
3) Deblended spatial resolution down to 30 pc to estimate the galaxy’s effective radius and constrain the properties of smaller structures within
4) First constraints on metallicity and ionizing strength of a galaxy at z=11

In addition to the z=11 galaxy, we will study the large number of (~30) known z ~ 6 – 8 candidates in this field plus new discoveries of fainter candidates at z ~ 6 - 11 and perhaps beyond in this exceptional strong lensing field. We waive exclusive access to all data obtained from this program, and will release reduced data products,
We propose to obtain deep 4.9-28.4 micron MIRI spectroscopy of three molecule-rich protoplanetary disks, known to show very bright water line emission in their Spitzer spectra. Infrared molecular emission from protoplanetary disks traces material near 1 AU - the terrestrial planet forming region. The deep spectra will be used to search for the rarest molecular species that JWST can detect, including heavy isotopologues of water, as well as important carriers of nitrogen and carbon. We will in particular search for H2_18O to measure the H2_16O/H2_18O ratio in disks and determine whether the oxygen is enriched in the heavier isotopologue as is seen in primitive solar system material. We will also search for warm NH3 and CH4 as signposts of a vigorous primordial chemistry in the terrestrial planet-forming region. As the volatility of the molecular carriers of carbon, nitrogen and oxygen determine the amount of each are available for accretion onto planets, these observations will provide a critical comparison to exoplanet atmospheric chemistry.

As a critical and necessary part of this proposal, we will obtain deep spectra of two bright asteroids for the construction of very high signal-to-noise ratio spectral response curves (SRFs). Such empirical SRFs are needed to robustly remove the strong, high-frequency fringes present in MIRI-MRS at the ~20% level, and were similarly critical for calibrating the Spitzer-IRS mid-infrared spectra of protoplanetary disks. Recognizing the importance of conservative fringe removal for other MIRI-MRS programs, we waive the exclusive access period so that other MRS spectra of bright point sources can realize their full scientific potential.
At z>6 (when the Universe is <1 Gyr old), luminous quasars are exceptionally active: their central engine is a rapidly accreting supermassive (~1e9 Msun) black hole which resides in an intensely star-forming galaxy that is ab order of magnitude more massive than typical galaxies at these redshifts. How can we account for such a rapid growth of these extreme sources? The exceptional quasar PJ308-21 may offer an answer. High-resolution HST and ALMA imaging demonstrates that the quasar host is undergoing a merger with one or more satellite galaxies. For the first time at these redshifts, host galaxy starlight is detected around a luminous quasar. A prominent Ly-alpha halo, detected with MUSE on the ESO/VLT, partially overlaps the companion galaxy. The data in hand already show all the agents of rapid galaxy growth at play: gas, dust, star formation, and nuclear activity. Here we propose to capitalize on the unprecedented capabilities of JWST to secure NIRSpec IFU observations, creating Halpha, Hbeta, [OIII] and [NII] maps which will enable: 1) a characterization of the ionized gas physical properties (metallicity, ionization parameter, powering mechanism) and a test for the presence of outflows; 2) an estimate of the stellar mass of the satellite galaxy; 3) a precise timing of the star formation event, which we will use to understand the role of the gravitational interaction in triggering the starburst; 4) a test of the origin of the Ly-alpha halo. These observations will lead to a fundamental new understanding of the build-up of massive galaxies and black holes in the early universe.
We propose to test the stability of MIRI Medium Resolution Spectroscopy for time series observations, such as for transiting exoplanets. Being a calibration proposal, we observe a control-type source that exhibits a small variation whose characteristics are known. We will observe the bright Algol-type eclipsing binary R Canis Majoris over an 9.5-hour period spanning secondary eclipse, using one grating position. The primary technical goals of our observations are: 1) to define the limiting instrumental noise ("noise floor") in time-series observations over small wavelength scales (pixel-to-pixel) that are the most relevant for spectroscopy, 2) to determine how to decorrelate and remove the instrumental noise, 3) to define the temporal stability of the instrumental fringing, and 4) to explore the implications of our results for exoplanet spectroscopy. The secondary star in R CMa is a K-dwarf, that will exhibit weak (0.4-percent) rotational lines of OH in its emergent spectrum. In addition to our primary technical goals, a secondary goal is a technical demonstration: we will use the secondary eclipse technique to measure the OH line spectrum of the K-dwarf in this binary system, just as exoplanet observers will seek to measure the emergent spectra of exoplanets in the thermal infrared. By demonstrating that we can derive an astrophysically credible spectrum of the K-dwarf to high signal-to-noise ratio, we will further validate the process of observing exoplanetary spectra with MRS. We will produce specific deliverables, including a python code to extract spectra from the focal plane images, with instrumental noise removed.
Massive O and B stars produce strong ionizing and far-ultraviolet radiation as well as powerful winds that ionize, heat, and impact their surround molecular clouds. This radiative and mechanical feedback can dramatically alter the subsequent star formation by injecting energy directly into the gas, by photodissociating molecules and ionizing atoms which alters the gas cooling, and by destroying the cloud by mechanical means or by photoevaporation. Thus, understanding the feedback process is essential to an understanding of star formation and the evolution of galaxies. The regions where this radiative energy is deposited are called Photodissociation Regions or PDRs and are key targets for JWST observations. All of the near-infrared continuum and line emission from star forming regions in nearby and low redshift galaxies to be observed by JWST arise in PDRs.

This is a Regular Archive, Theory proposal, to develop PDR models and diagnostic modeling tools to analyze the line emission from PDRs. We concentrate on the H2 rotational emission, the CI recombination lines, the OI fluorescent lines, and the Fell fine-structure lines which reveal the gas heating rate and thermal energy content (H2, CI, Fell), the FUV radiation field strength and penetration (H2, OI), the H2 formation rate (H2), the thermal pressure (Fell), and the cloud disruption by photoevaporation (OI).
We propose to observe the Ring Nebula, NGC 6720, at unprecedented spatial resolution and spectral sensitivity using MIRI, NIRSpec and NIRCam, with the aim of measuring and analyzing the emission from a range of atomic, molecular and particulate components commonly found in astrophysical environments. We will use this planetary nebula (PN) as an astrophysical laboratory, with a well-defined geometry and a single exciting central star. With Spitzer, PAH emission and strong mid-IR molecular H2 emission have already been detected from the O-rich PN NGC 6720. We will image the entire nebula in multiple NIRCam and MIRI filters to enable us to spatially resolve the different gas and PAH components, combining these with high spatial and spectral resolution NIRSpec and MIRI IFU spectroscopy at two positions, one on an isolated clump at the inner edge of the bright ring and the other on the main ring itself. We will use the data to analyze and model the physical conditions in the ionized and molecular gas in order to probe how these, together with the radiation field, influence spatial variations of the PAH charge balance, size and structures deduced from the observed PAH band ratios. This will allow us to investigate how PAHs and other molecules form, evolve and survive in clumpy, irradiated environments.
We propose a pilot study of near-infrared reflectance spectra from dust in the Kuiper Belt regions of 4 nearby debris disks, 49 Cet, HD 32297, beta Pic, and HD 181327, using the NIRSpec IFU. These disks are spatially extended, each subtending several arcsec in scattered light, with already measured near-infrared surface brightnesses from HST/NICMOS. They are therefore the easiest systems to study using high contrast spectroscopy. Our targets have ALMA CO emission indicative of the presence of volatile-rich planetesimals, similar to comets and KBOs in our Solar System. We propose to use high SNR (>200), near infrared spectra at 0.6 - 5.3 micron to (1) search for solid-state reflectance features at 1.5, 2.0, and 3.2 micron from volatile frosts such as H2O, (2) constrain the dust grain properties (e.g. composition, size) from the solid-state features and the color of the scattered light, and (3) map the particle composition and size as a function of position in the disk. In doing so, we hope to understand whether exoKuiper Belts in exoplanetary systems contain reservoirs of volatiles, that have been critical to the development of life on Earth, and are continuing to build exoplanets via giant collisions. At the present time, there are no plans by any of the Guaranteed Time Observers (GTOs) or Early Release Science (ERS) programs to obtain reflectance spectra for a debris disk. Therefore, these data would be unique. Finally, these observations would provide a pathway to develop Reference Differential Imaging (RDI) and Spectral Differential Imaging (SDI) PSF subtraction techniques for the NIRSpec IFU.
Comets are our most direct link to the earliest stages of the formation and evolution of the solar system. The abundances and spatial distribution of major gas species (H₂O, CO₂, CO) and major dust species (silicate and carbonaceous) in comet comae provide direct insight into the chemistry and internal composition of primitive bodies. Comets and asteroids delivered these materials and pre-biotic precursors to the terrestrial planet zone potentially catalyzing life. JWST will advance a key goal of planetary science: ascertain the content, origin, and evolution of the solar system and the delivery of pre-biotic volatiles by evaluating the characteristics of refractory materials, ices, organic species and volatiles of comets. This JWST program is designed to determine the physico-chemical properties of material in the inner 3000 km coma of comet C/2017 K2 (Pan-STARRS) near perihelion. JWST is indispensable for this science because its sensitivity to faint surface brightness extended emission combined with the spectral resolving power (2400+) and continuous spectra grasp (2.87-28.8 micron) enables spatial-spectral mapping to trace the coma distribution of dust and gas simultaneously. Evaluating the characteristics of refractory materials, ices, organic species, and volatiles of comets enhances understanding of the origin and evolution of our solar system and the potential for life elsewhere. Processes that occurred in our protoplanetary disk must be taking place at some level in the youngest of these exoplanetary systems, although the details will differ. The narrative tale gleaned through the JWST study of comets is an account
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01567
Program Title: Early Galaxy Assembly Uncovered with ALMA and JWST: A Remarkably UV and [CII] Bright, Strongly Lensed Sub-L* Galaxy at z=6.072
Principal Investigator: Seiji Fujimoto
PI Institution: Cosmic Dawn Center, Niels Bohr Institute

The authors propose NIRCam imaging and NIRSpec IFU spectroscopy for two multiple images of a strongly lensed Lyman break galaxy at z[CII]=6.072 discovered by a 100-hr ALMA Lensing Cluster Survey. Among normal star-forming galaxies at z>5, both of the multiple images are the brightest lensed sources known, with the H-band continuum of H~23.7 mag and the [CII]158um line flux of ~20 mJy due to the high magnification factors. One of the lensed images is stretched over a 6“-scale arc crossing the critical line, making a z=6 sub-L* galaxy (Mstar~10^9 Msun) with extremely faint dust emission (L_FIR~10^8 Lsun) highly visible. Exploiting these unique ALMA lensed sources with well characterised cold inter-stellar medium (ISM) properties, this JWST program unveils the remaining key elements of their hot ISM and stellar properties by 1) mapping out star-forming regions and stellar mass distributions down to ~20-80 pc scales and ~32-35 mag after the lens correction, 2) obtaining rest-frame optical lines of Balph, Hbeta, [OIII]5007, [NII]6583, [SII]6716, 6731 to determine ionizing sources on the BPT diagram and to estimate electron density, metal gradients, and dust attenuation, and 3) probing kinematics of star-forming clumps and the rotation curve of the host galaxy disk up to ~2.5xeffective radius to test the existence of inflow/outflowing gas clumps and a potential decline of the rotation curve as reported in baryon-dominated massive galaxies at z~1-2. This joint ALMA and JWST study is an essential step in providing a representative view of the early galaxy assembly at z=6 with building blocks of both dark matter and baryon down to globular cluster scales.
We propose to use JWST and NIRCam to carry out a search for the faintest trans-Neptunian objects (TNOs) ever detected. We will detect 30 objects as small as 7 km at distances up to 45 AU, placing strong constraints on the small size distribution, and thereby testing competing models for the formation and collisional evolution of trans-Neptunian objects. We will also probe deep into the size regime of Centaurs and Jupiter Family Comets, empirically measuring the size distribution of similarly-sized TNOs where Centaurs and JFCs are sourced. The result of this program will be a huge advance in our understanding of the dynamical and chemical evolution currently occurring in the distant Solar System. This experiment can only be carried out with JWST.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01571
Program Title: PASSAGE--Parallel Application of Slitless Spectroscopy to Analyze Galaxy Evolution
Principal Investigator: Matthew Malkan
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We propose a wide field pure-parallel survey of emission-line galaxies spanning a wide range of cosmic time 1<z<8, with the NIRISS grism, unbiased with respect to cosmic variance or photometric pre-selection.

With the suite of rest-frame optical emission lines detected, we will measure spatially resolved extinction-corrected star formation rates, gas ionization properties, and metallicities across “Cosmic Noon” (z=1-3.5), reaching down to stellar masses of 1e7 Msun, enabling key tests of theoretical models at 0.5 kpc resolution. At z>7 we will spectroscopically discover many dozens of the brightest Ly-alpha line emitters in the reionization epoch, and also detect Ly-break galaxies independent of their Ly-alpha lines. This will provide the first unbiased determination of the EW(Ly-a) distribution, and potentially evidence for ionized bubbles. We will also obtain stellar abundances in bright galaxies, and a census of brown dwarfs deep into the Galactic halo.

We expect to observe 80 shallow fields, 33 medium and 11 deep independent fields at high galactic latitudes, detecting several thousand galaxies (with line SNR > 5) reaching star formation rates (SFRs) down to <1 Msun/yr. Wide and continuous spectral coverage (1.0-2.2um) will secure rest-frame optical emission line ratios in the medium/deep fields. The all-sky coverage will remove cosmic variance, and uncover rare bright galaxies for follow up opportunities.

To maximize benefit to the community and JWST follow-up opportunities, we will rapidly release fully-reduced spectra and images in user-friendly formats, as well as catalogs of redshifts, SFRs, reddenings, metallicities, and 2-D maps of resolved line emission.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01572
Program Title: Mapping, resolving and penetrating into the dusty Spiderweb protocluster with unique Pa-beta imaging
Principal Investigator: Helmut Dannerbauer
PI Institution: Instituto de Astrofisica de Canarias
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We propose to conduct a unique and very efficient Pa-beta imaging (1.4hrs science time!) of the best-studied galaxy cluster in formation, called "Spiderweb" protocluster, at z=2.16, with the NIRCam F405N filter. Our primary goal is to map the entire star formation activities across this starbursting protocluster, and within individual galaxies therein, by spatially resolving the dust-enshrouded star forming regions. We will unveil all the star forming activities down to a SFR of 3.5 solar masses per year, free from dust extinction, making a complete census of the protocluster (core). By mapping the SFR(Pa-beta)/SFR(UV) ratio within the galaxies in combination with the existing HST/ACS data, we will pinpoint the locations of dusty star-forming regions within the young cluster galaxies, for a subset of members even matching at a similar spatial resolution of 1kpc ALMA dust continuum imaging. Taking advantage of the multi-wavelength, ancillary data available for the target field, we will calibrate the different star-formation indicators such as H-alpha, Pa-beta, dust continuum and rest-UV to NIR SEDs and we will determine the star-formation mode of each member galaxy. Simultaneously for free, we will observe with F115W (rest-U) and F182M (rest-V) at the SW channel of NIRCam, to map the distribution of quiescent and star-forming regions (and stellar mass surface density) for >100 known cluster members (out of which 61 are z-spec confirmed). The proposed Pa-beta imaging - as this line falls luckily in F405N - is the most powerful, unbiased approach to reveal the complete picture of the stellar mass assembly process in this young protocluster environment at cosmic noon.
We propose a JWST treasury program to obtain MIRI-MRS spectra of the complete sample of protoplanetary disks from the ALMA-DHARP survey, which obtained high resolution mm-wave images of disk substructures. With MIRI-MRS data, we can produce gas-phase inventories and radial abundance profiles of molecules in the terrestrial planet-forming regions of the DSHARP disks. With these combined datasets, we create the unique potential to study how global disk evolution and planet formation are interconnected with disk chemistry. Ultimately, the chemical makeup of the disk determines the chemical reservoir out of which planets form, and therefore, the composition of planets. In addition to releasing reduced spectra, our team will produce and release several higher-level data products to the community, including line fluxes, bulk molecular parameters (rotational temperature, column density, and emitting area), and molecular abundance ratios. This combined dataset will have the power to support a broad range of investigations, and will have lasting legacy value for both the planet formation and exoplanet communities.
Observations of Uranus by the MIRI instrument made in the GTO program 1248 will be analyzed for spatial variability of temperatures, composition and possible stratospheric hazes. We concentrate this effort on three particular topics. (1) Determine the deep tropospheric structure. Its global mean is a key to understanding the accuracy of a model whose spectrum is now used as a calibration standard for submillimeter and longer wavelengths. This is very important in light of our ongoing analysis on Herschel and ISO observations that imply a protosolar mixture of helium and hydrogen, making Uranus unlike the helium-depleted atmospheres of giant planets Jupiter and Saturn. Testing this model critically involves examining the center-to-limb structure of 9-11 micron radiances to diagnose the presence of a warm, emitting particulate layer in the stratosphere. (2) Determine upper-tropospheric/lower-stratospheric temperatures and spin states of H2, providing an indirect constraint on vertical motions. (3) Determine the temperature structure and H2 spin state of the stratosphere using center-to-limb behavior of H2 quadrupole and dimer lines that will distinguish between alternative models derived from analysis of Spitzer IRS observations. These results will be compared with Voyager-2 IRS, Spitzer IRS (disk-averaged), and spatially resolved ground-based thermal images and spectra. This comparison will clarify ambiguities in their analysis and measure long-term evolution of atmospheric properties one season after the 1986 spatially resolved Voyager-2 measurements of thermal emission.
Despite ~50 years of compact object studies in the Galaxy, the physics of relativistic jet launching remains an active and open field of research. There has been important recent progress in development of state-of-the-art MHD simulations, but how these determine the emission properties is now a major focus. A deeper understanding requires us to probe rapidly changing conditions in the outflowing plasma close to the jet base, for which only piecemeal studies have been possible to-date. A key observational feature, the spectral break above which the jet becomes optically thin, provides a crucial link between light and plasma properties. It is a variable feature that needs to be tracked and linked to other jet properties, and is known to pass through the mid-infrared band.

We propose to detect this jet spectral break, and monitor rapid flux and spectral shape variations in outbursting Galactic black hole binaries using the MIRI LRS mode, to provide estimates of the variable magnetic (B) field strength and physical dimensions of the jet base. There is evidence that these properties are subject to violent variations on timescales <~1 seconds, which can have important consequences for our understanding of the inner jet B field dynamics and particle acceleration mechanisms. We will measure the B field strength and radiative energy of the jet, while any variability in flux and frequency will provide unprecedented constraints on the speed and magnitude of B field changes. The break is predicted to lie in the infrared regime during typical jetted outbursts of transient black hole X-ray binaries, so this science is ideally suited for MIRI LRS observations.
This is a NIRSpec IFU proposal to measure the 1-5 \(\mu m\) spectrum of a few select objects known to have well-studied PAH features longward of 5 \(\mu m\). Apart from the 3.3 \(\mu m\) PAH band and \(\sim3.2-3.6 \mu m\) plateau, PAH spectroscopy across this region has been widely overlooked. The PAH model predicts many important, but weaker, features between 1-5 \(\mu m\). JWST’s unprecedented sensitivity, spectral resolution, and continuous 1-5 \(\mu m\) wavelength coverage make it possible, for the first time, to measure and fully characterize these features. Although, far weaker than the well-known bands, their frequencies and relative intensities contain fundamental information about the interstellar PAH population that is not accessible through the 5-15 \(\mu m\) PAH bands, such as the amount of cosmic nitrogen and deuterium sequestered in PAHs. The goal is to make interstellar PAH spectroscopy a more precise and complete probe of their environments by expanding the spectral bandwidth to include the full 1-5 \(\mu m\) range. Since PAHs play important roles in the astrophysics of many different astronomical environments, from H2 formation to cloud collapse times and complex prebiotic molecule formation in planet forming regions, these observations will fundamentally impact our understanding of many astrophysical processes. PAH features are going to be an important part of many, if not most, of the JWST NIRSpec and MIRI measured spectra and this will likely be the last opportunity to measure the weak PAH and PAH related emission features in the 1-5 \(\mu m\) region for a very long time. It is extremely important to get the most out of NIRSpec concerning PAHs as is possible at this time. The proposed observations will do just that.
Observations of Neptune by the MIRI instrument made in the GTO program will be analyzed for spatial variability of temperatures and composition. The scientific questions the program addresses emerge from previous and ongoing work using spacecraft and ground-based observations of Neptune’s atmosphere. This work will (1) produce spatially resolved unambiguous maps of Neptune’s stratospheric temperatures and composition, constraining the 3-dimensional structure and circulation of Neptune’s middle atmosphere; (2) establish relationships between Neptune’s visible structure and its 3-dimensional temperature and wind field, and (3) examine the relationship between storms and waves in the atmosphere. This work will help understand differences between dynamics of Neptune’s and Saturn’s atmosphere, both with a similar seasonal forcing arising from nearly the same axial tilt. The determination of Neptune’s temperature structure will enable a refinement of far-infrared through submillimeter spectral models of Neptune, which serves as one of several primary calibrators for millimeter and submillimeter astronomy, e.g. for ALMA. The results are also important because Neptune is viewed as an archetype for similar-mass exoplanets known to exist in our galaxy from Kepler observations.
Proposal Category: GO  
Scientific Category: Solar System Astronomy  
ID: 01604  
Program Title: Dynamics and Temporal Variability in the Atmosphere of Neptune  
Principal Investigator: Glenn Orton  
PI Institution: Jet Propulsion Laboratory  
Co Investigators
Leigh Fletcher University of Leicester, Julianne Moses Space Science Institute, Heidi Hammel Space Science Institute, James Sinclair Jet Propulsion Laboratory, Henrik Melin University of Leicester, Michael Roman University of Leicester, Thomas Greathouse Southwest Research Institute, Naomi Rowe-Gurney University of Leicester

We propose short sequences of spatially resolved spectroscopic thermal observations of Neptune using MIRI within Cycle 1 to follow up GTO observations in order to determine the variability of temperatures, composition and dynamics on intermediate- to short-term time scales. Specific science goals include a deeper understanding of the influence of radiation and dynamics on polar and quasi-polar phenomena, storms and planetary-scale changes, longitudinal thermal waves and time-variable oscillations, as well as results of "cometary" atmospheric impacts. Despite the well-documented intermediate- and short-term variability of Neptune's cloud structure, no observations have been made on similar time scales to understand the correlated variability of temperatures, clouds and 3-dimensional dynamics.

MIRI is the ideal instrument for making the first of such observations. The implications of these results have a broad application, as Neptune represents a cold end-member of a large segment of a populous class of similar-sized exoplanets. Determination of Neptune's dynamics will provide insight into these bodies, e.g. providing clues as to the origin of rotational variability originates from inhomogeneous distributions of temperatures or composition versus cloud cover.
We propose to obtain an inventory of bulk volatiles in the youngest protostellar envelopes, just prior to the final assembly of protoplanetary disks. This will trace late-stage chemical evolution of young stellar envelopes, and establish the initial conditions of water and organics for comparison to observations of protoplanetary disk chemistry. To accomplish this goal, we will take advantage of the dense cluster of class 0 protostellar envelopes in the Serpens Main cloud. This cluster is sufficiently dense, and is located at a near-optimum distance and low galactic latitude, to allow us to use the multi-object spectroscopy mode of NIRSpec to obtain 2-5 micron ice absorption spectra toward ~150 highly extincted field stars, including at least ~30 sightlines directly through the protostellar envelopes. Using the incredible sensitivity of NIRSpec, we will be able to probe extinctions as high as AV~75 mag needed to reveal rare ice species. We estimate that we will obtain ~5 lines of sight through each of 6-8 protostellar envelopes, providing radial maps of relative ice abundances on scales of a few thousand au. The column densities of bulk ices are readily observed in the 2-5 micron region, including much of the oxygen-bearing inventory, as well as simple organics (e.g, H2O, CO2, CO, CH3OH). Particularly methanol ice is a critical, yet poorly understood, cornerstone of pre-planetary organic chemistry. The high column densities also allows for sensitive searches for the rare isotopologues 13CO, 13CO2, and HDO. The two former enables studies of dust grain shapes, while the latter may yield the first robust measurements of the deuteration fraction of pre-planetary material.
In the early universe, at the lowest masses where gravity is in a tug-of-war with the energy injected by internal events (stellar feedback) and outside events (reionization, environmental effects), the dominant factors that govern the growth of the smallest structures are still speculative. Archeological studies of low-mass galaxies in the Local Group (LG) have striven to answer this question through detailed analyses of the oldest stars. Yet, the LG is, by definition, a complicated system and the history of its satellite galaxies are intertwined with their evolution in the shadow of their massive host. The only laboratory to truly measure how galaxies at the limit of structure formation grow is a very low-mass system that is isolated.

Leo P is an isolated, extremely low-mass (M*~10^5 Msun), metal poor (<3% Solar), gas-rich galaxy just outside the LG at 1.6 Mpc. It is the quintessential system to test theories of how the smallest structures in our universe survive and grow. We will image the resolved stars in Leo P to below the old main sequence turn-off, a depth unreachable with HST but achievable with JWST, to derive the ancient star formation history of the galaxy. The star formation history will test if (i) early star formation in Leo P was `quelled", as predicted nearly uniformly by reionization models, and then re-ignited, (ii) Leo P has a delayed onset in star formation suggesting the accretion history of baryons may be dependent on environment at low masses, or (iii) Leo P has constant star formation across all epochs which is not predicted by cosmological models in this mass range and which would also be in tension with reionization models.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01618
Program Title: Searching Our Closest Stellar Neighbor for Planets and Zodiacal Emission
Principal Investigator: Charles Beichman
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Alpha Centauri A is the closest solar-type star to the Sun and offers an unique opportunity to detect both a mature gas giant planet (consistent with existing radial velocity constraints) and a zodiacal dust cloud. A carefully planned observational sequence using the MIRI Coronagraph (F1550C) and innovative post-processing would be sensitive down to a radius limit of 0.5–0.7 R-Jupiter for planets within ~3 AU (~2.5") around alpha Cen A where models predict a region of stability against disruption by alpha Cen B. These same observations would be sensitive to a level of zodiacal emission only a few times brighter than that of the Sun’s, an unprecedented level not even achieved by ground based interferometers. The proposed observations would probe the limit of JWST high contrast imaging on a star that offers the best chance for the ultimate detection of Earth analogs by future ground and/or space based facilities. The experiment is admittedly high risk, but the prospect of directly imaging a planet around our closest stellar neighbor is an exciting one.
Proposition Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 01619
Program Title: Dust Formation in a Primitive Environment
Principal Investigator: Martha Boyer
PI Institution: Space Telescope Science Institute
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Observations suggest that Asymptotic Giant Branch (AGB) stars contribute significantly to the dust budgets of galaxies, from our own Presolar Nebula to the Magellanic Clouds. However, models suggest their contribution should decrease with metallicity, possibly becoming overshadowed by supernovae and interstellar grain growth in primitive environments. Recent observations of nearby dwarf galaxies contradict this prediction, showing that AGB dust forms easily at low metallicity, which allows AGB stars to contribute dust as early as 30 Myr after they form in the early Universe. Because of limitations in sensitivity, absolutely nothing is known about the mineralogy, the grain properties, or the even the quantity of this extremely metal-poor dust. We propose observations of the nearby dwarf galaxy Sextans A, which is the Goldilocks galaxy for a comprehensive assessment of the effect of primitive abundances on dust formation because it 1) is nearby enough to escape crowding and sensitivity limits at the longest wavelengths, 2) is extremely metal-poor (just ~7% solar or 2.5x lower than the SMC), 3) is known to harbor a large AGB population that spans the full AGB mass range, 4) many of these AGB stars are known to be dusty, and 5) dust has been detected in its interstellar medium. No other galaxy comes close to providing the opportunities afforded by Sextans A. We will image the star-forming disk with NIRCam and MIRI from 0.9-25.5 microns, with careful filter selection to fully sample key molecular and dust features. We will also obtain LRS spectra of 6 known dusty stars to guide our interpretation of the photometry around the most prominent infrared features from 5-12 microns.
We may be at the brink of a paradigm shift in our understanding of how protoplanetary disks evolve, a shift that would have major implications for planet formation. Departing from MRI-driven turbulence, the emerging theoretical scenario relies on MHD disk winds to vertically extract angular momentum and thus enable accretion of disk gas onto the star. However, wind-driven accretion requires that: i) MHD winds are radially extended out to tens of au; and ii) wind mass loss rates are an order of magnitude higher than in jets, i.e. comparable to mass accretion rates. Here, we propose to carry out deep NIRSpec/IFU spectro-imaging from ∼1 to 5 micron to simultaneously cover multiple jet, wind, and accretion diagnostics and specifically test these key theoretical predictions. With an IFU spaxel of 0.1", our sample of five well-characterized edge-on disks in Taurus, with no or minimal envelope, is ideally suited to map the radial and vertical extent of MHD disk winds. By setting the sensitivity to detect over ten H2 rovibational lines and three critical [FeII] lines, we will measure densities and temperatures in the wind and jet, respectively. In combination with the first direct measurements of the wind vertical extent, we will estimate mass loss rates. Through the first sensitive high-resolution thermal images in the CO fundamental we will also probe the wind closer to its launch height and reveal to what extent volatiles are depleted from the disk. Finally, by covering the stellar masses over which jets and winds have been inferred from ground-based data, our spatially resolved images will guide mass loss rate estimates for all sources that have slow wind signatures.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01626
Program Title: Achieving a Revolutionary Panchromatic View of Early Galaxy Growth through NIRSpec/IFU Observations of 12 Massive z>6.5 Galaxies with ALMA-derived [CII] redshifts
Principal Investigator: Mauro Stefanon
PI Institution: Universiteit Leiden
Co Investigators: Rychard Bouwens Universiteit Leiden, Pascal Oesch Observatoire de Geneve, Daniel Stark University of Arizona, Renske Smit Liverpool John Moores University, Rebecca Bowler University of Oxford, Valentino Gonzalez Universidad de Chile, Ryan Endsley University of Arizona, Sander Schouws Sterrewacht Leiden, Manuel Aravena Diego Portales University, Pratika Dayal Kapteyn Astronomical Institute, Ilse De Loop Universiteit Gent, Yoshinobu Fudamoto Waseda University, Luca Graziani Universita di Roma La Sapienza, Jacqueline Hodge Universiteit Leiden, Hanae Inami Hiroshima University, Ivo Labbe Swinburne University of Technology, Yuexing Li The Pennsylvania State University, Themiyi Nanayakkara Swinburne University of Technology, Raffaella Schneider Universita di Roma La Sapienza, Paul van der Werf Universiteit Leiden, Cameron White University of Arizona

One of the most significant longstanding questions is how rapidly the most massive galaxies build up in the early universe. Addressing this question directly has not been possible due to a lack of a sizeable sample of spectroscopically-confirmed, especially high-mass galaxies in the early Universe on which to execute physical studies. Excitingly enough, we are now on the brink of making significant progress thanks to identification of a large sample of massive galaxies in the z>6.5 universe from ongoing ALMA large program observations. Galaxies have spectroscopic redshifts from [CII] and show prominent emission in the far-IR. We propose to obtain NIRSpec IFU R100 observations for 12 of the brightest [CII]-detected sources from this sample. Our IFU observations will provide us with a unique high spatial resolution view of both the stellar mass and unobscured star formation rates in these high-mass sources, as well as the metallicity and radiation fields. Thanks to the size of our sample, we will be able to evaluate the efficiency of star formation in galaxies at early times, determine the impact of merger-driven star formation on stellar mass growth in z>6 galaxies, and explore correlations between a wide variety of different physical properties deriveable from the joint JWST+ALMA data set. The significantly higher mass/SFRs of sources in our sample as compared to JADES and CEERS program will allow us to uniquely explore the properties of galaxies to very high masses. The resulting JWST+ALMA dataset will establish a reference sample of reionization epoch galaxies with unique panchromatic information for the JWST era and beyond.
HD 189733b is the archetype of hot Jupiters. We propose to measure the molecular inventory and cloud composition in its atmosphere to high sensitivity. We will observe its transit spectrum over a large range of wavelength, using 5 transits: two observed with NIRCam grisms, and three with MIRI MRS. The resulting composite transit spectrum spans from 2.4 to beyond 20 microns, and includes strong bands of the major atmospheric molecules (water, methane, carbon monoxide, and carbon dioxide), as well as strong bands of important minor species (HCN, ammonia, and hydrogen sulfide). There is evidence that exoplanets show a mass-metallicity trend that differs from planets in our Solar System when water vapor (oxygen) is used as the proxy for metallicity. We will measure the atmospheric metallicity of HD 189733b to a precision of 0.025-dex using CNO elements, and determine unequivocally whether it is consistent with the Solar System's relation, or not. We will also probe atmospheric chemical disequilibrium by detecting minor species that are depleted (methane) or enhanced by vertical transport (HCN), or produced by photochemistry (hydrogen sulfide, from sulfur photochemistry). Our analysis will successfully deal with possible interference due to stellar activity, and we will measure the cloud composition using vibrational modes in the thermal IR. Although this planet transits a very bright star (Kmag=5.54), we are using moderately high spectral resolution and the observations will not be hindered by saturation. These are low-risk observations for Cycle-1 because the signals to be measured are large, and the scientific return is substantial.
The environmental dependence of galaxy properties today requires an accelerated assembly history in high density environments. Protoclusters, the overdense regions of the universe that ultimately collapse into massive galaxy clusters, contribute a significant fraction of all cosmic star formation during the era of reionization. The galaxy overdensity may enhance the escape of ionizing photons, making protoclusters crucial in driving the timing and topology of cosmic reionization. We propose to measure the brightest rest-frame-optical emission lines from spectroscopically-confirmed galaxies comprising the largest overdensity yet identified near the midpoint of cosmic reionization, z70D. Eight protocluster members, identified by their Lyman-alpha emission, are the primary targets for these NIRSpec MOS observations, which will measure rest-frame optical emission lines between the [OII] doublet and hydrogen Balmer alpha lines. We aim to measure the transmission of the IGM in and around an ionized, cosmic bubble, determine the physical properties of the galaxies that ionized the bubble, and compare them to field galaxies at $z > 3.37$ (observed simultaneously). We will measure the Lyman-alpha escape fraction and the Lyman-alpha velocity offset, information required to map spatial variation in IGM transmission. Protoclusters at this redshift are predicted to contain significant amount of cold gas, possibly triggering high specific star formation rates and accelerating the chemical evolution of the galaxies; ideas we will test by directly measuring diagnostic emission-line ratios.
The tip of the red giant branch (TRGB) is arguably one of the most precise and efficient distance indicators for nearby galaxies. TRGB distances are a key rung in the distance ladder, contributing to a precision measurement of the Hubble constant ($H_0$), independent of Cepheid variable stars. These TRGB distances are measured with HST F814W (i.e., I-band) observations where the luminosity of the TRGB has only a modest and well-characterized dependence on metallicity.

In the NIR, the TRGB is up to 2 mag brighter offering profound observational gains. Simply put, JWST is capable of measuring TRGB distances out to $\sim$50 Mpc over a 125x greater volume than HST, and reaching galaxies with diverse properties across all morphological types. The TRGB with JWST will become the primary distance indicator in the nearby universe.

However, the luminosity of the TRGB in the NIR is expected to have a greater dependence on metallicity and possibly stellar age. Thus, for JWST to be used for TRGB distance work, it must be empirically calibrated and robustly tested. We propose observing 4 nearby galaxies that have existing HST ACS and WFC3 IR observations from a JWST preparatory program. We will calibrate the TRGB in the F090W, F150W, F277W, and F356W NIRCam filters and the F090W and F150W NIRISS filters in parallel. We will quantify the precision of TRGB distances obtained with simultaneously imaged F090W+F277W filters, which offers a $\sim$50% increase in efficiency of JWST observations for distance work. A calibration in this first cycle of JWST will enable TRGB distances with JWST throughout the mission lifetime and charter a path to reduced uncertainties in the local measurement of $H_0$.  

Evan Skillman University of Minnesota - Twin Cities, Martha Boyer Space Telescope Science Institute, Andrew Dolphin Raytheon Company, Max Newman Rutgers the State University of New Jersey
The dynamics and accretion of pebbles in protoplanetary disks are currently proposed to be decisive in forming planetary systems and determining their architecture and composition. Pebbles are expected to drift efficiently as soon as they reach mm-cm sizes at orbital radii of ~100 au, therefore feeding the inner disk with planet-building material. Depending on a lower or higher mass-flux of pebbles that makes it into the inner 2-3 au, models propose that systems of terrestrial planets rather than super-Earths would form. ALMA images of disks around 1-3 Myr-old stars have revealed that a range of pebble drift efficiencies exists, with some disks retaining pebbles at 50-200 au in systems of rings. While ALMA observations easily reveal pebbles retained in the outer disk, they cannot inform on the pebble mass flux into the inner rocky-planet-forming disk region. In this program, we will use the infrared water spectrum as a tracer of the inward mass-flux of pebbles that drift into the inner ~3 au in disks, by measuring water columns and their relation to the radial distribution of disk pebbles. While a connection between inner disk water and outer dust disk radius has been found using blended Spitzer spectra, the increased resolution of JWST-MIRI will for the first time separate optically thin from thick emission lines, providing a dramatic improvement in water column density measurements. We will provide estimates of pebble mass-fluxes delivered to inner disks in a luminosity-controlled sample of representative dust disk evolution types, and forward model those into inner disk planetary systems for comparison to ~1-10 Earth-mass exoplanets.
We propose a cornerstone study of the jet/outflow connexion with JWST in the remarkable DG tau B system. ALMA observations have revealed a narrow conical rotating CO outflow whose properties are challenging the traditional interpretation of these molecular outflows as swept up material. Instead its properties appear compatible with a magnetic disk wind origin. These findings, if fully confirmed, have a crucial impact on proto-planetary disks. However, we are critically missing resolved spatial information on any warm wind component filling the gap between the hot (T=10^4 K) and fast (V=100 km/s) jet and the cold (T=10 K) and slow (V=10 km/s) molecular outflow. We propose to map with MIRI-MRS, NIRspec-IFU & NIRCAM the inner 5" (=700 au) of the prototypical DG Tau B outflow in ro-vibrational and rotational H2, [Fe II], [S I] & [Ne II] emission lines. The proposed observations will establish for the first time a global view of the mass loss process in a young solar twin and discriminate between the different models for the origin of outflowing CO cavities. These results will provide critical insights into the importance of mass loss and magnetic field in proto-planetary disk evolution.
A polluted white dwarf hosting a planetary debris disc is experiencing an infrared outburst on a scale unprecedented in decades of observations. Recent follow-up photometry confirms the system remains highly active, and we propose multi-wavelength monitoring across a range of timescales to follow this event as it unfolds.

There is compelling evidence that planetary systems survive through stellar evolution and emerge dynamically active around white dwarfs. WD0145+234 is a rare example where emission from circumstellar gas and dust accompanies the photospheric metals. It recently brightened by over one magnitude in the infrared, likely due to emission from dust liberated in planetesimal collisions. Catching it in such an active state gives us a ringside view of white dwarf debris disc evolution in real time.

As one of the brightest representatives of its class, the system is ripe for mineralogical characterisation, and the collisional activity makes a strong case for a search for variation. If optical studies show changes in the photospheric metals, they would be the first of their kind, so taking infrared spectra in parallel is the best way to maximise the science return.

Timely infrared observations are critical to understanding the nature of this spectacular event. Our program will investigate the composition, dynamics, and evolution of this evolved planetary system, and the insights gained will be applicable across the population.
We propose deep NIRSpec and MIRI IFU spectroscopy targeting 3 galaxies at z=6.0-7.2 covered by ALMA [OIII]88um observations in order to derive gas-phase metallicities at z>6 using the reliable direct electron temperature method. Accurate gas-phase metallicities are crucial for understanding the formation and growth of early galaxies, but diagnostic calibrations to infer metallicity from strong-line ratios have not yet been established at high redshifts. Obtaining temperature-based metallicities of z>6 sources represents the most direct and robust solution to this problem. Although the direct method usually relies on temperature-sensitive auroral lines that are too faint to detect at z>6, we will accomplish this goal by combining measures of the temperature-sensitive far-infrared fine structure line [OIII]88um (from ALMA) with rest-frame optical lines (Ha, Hb, [OIII]4959,5007, and density-sensitive [OII]3726,3729 from JWST). Our program will deliver robust measures of the mass-metallicity relation to z=6-7 along with accompanying constraints on dynamical and gas masses, ionization parameter, and ionizing spectral shape. These constraints will allow us to understand the formation of luminous z~6 sources, the role of feedback in governing their growth, and their impact on cosmic reionization. Most significantly, direct-method metallicities derived from this program will serve as the first calibrating `anchor’ for statistical studies of metallicities and ionization parameters for galaxies in GTO/ERS and other samples, derived using the strong-line method. The combination will provide robust data for understanding early galaxy formation and the sources of cosmic reionization.
The New Horizons 2015 encounter with the Pluto system unveiled a remarkably active world, with a highly variegated surface and a chemically-rich atmosphere with extensive haze. It raised new fundamental questions about Pluto’s climate evolution, chemistry and energy balance of the atmosphere, and about the thermal and compositional properties of Pluto’s and Charon’s surfaces. In a highly complementary dataset to New Horizons, we will combine MIRI and NIRCam observations to address these topics. NIRCam filter imaging (3 visits, 4 SW filters) will map the albedo and methane ice distribution with resolution comparable to HST visible imaging, providing key tests for volatile transport models. MIRI imaging (6 visits, 4 filters) will yield separate thermal lightcurves of Pluto and Charon, determining the surface thermal and energetical properties and further constraining Pluto’s distribution of terrains. These data will also provide a definite test of the scenario of haze control of Pluto’s atmosphere thermal structure. A deep MIRI/MRS spectrum will give new insights on Pluto’s atmosphere composition, including yet undetected species (e.g. C3H8, C4H2), which are expected from photochemical-microphysical models, with additional implications for the atmosphere radiative balance. MIRI/MRS will also reveal the 5-15 micron reflected spectrum of the dark/red units of Pluto, where bands due to hydrocarbon ices and irradiation products are expected; a similar study will be performed on Charon using MIRI/LRS, searching for non-H2O ice signatures. Observational results will be interpreted in the framework of self-consistent and validated atmospheric and climatic models.
JWST, despite not being designed for observing high time-resolution phenomena, can be an unparalleled tool for such studies, opening wide the sub-second infrared timescale regime, if timing systematics can be controlled. Rapid time-domain studies, such as lag measurements in accreting sources and Solar System occultations, require both precise inter-frame timing and knowing when a time series begins to an absolute accuracy significantly below 0.5 s.

With this calibration proposal, we will support rapid time-domain studies, by measuring the mission clock calibration and drift between commanded resets from the ground (down to an ~40 ms level). Even if the clock only reaches its ground-based accuracy requirement of 0.5 s, we will deliver a technique that provides a factor of ~5 improvement with a minimal calibration overhead. The science-deliverables will be useful for a broad cross-section of the time-domain community.
Whilst exoplanet campaigns have discovered thousands of exoplanets at small radii, only rare planets more massive than Jupiter have been detectable at distances greater than 10 au. Nevertheless, these outer regions have instead been explored indirectly through observations of debris disks at tens of au. Over the last decades these observations have indicated the presence of planets shaping their structures, e.g. forcing disk eccentricities or carving gaps in wide disks, but the predicted planets were rarely within the detectable mass range. It is only now with JWST that we can directly detect these types of planets. We propose to use MIRI 15um coronagraphy to detect the planets carving the gaps in three wide belts discovered with ALMA: HD107146, HD92945 and HD206893. We predict the mass of these planets to be in the range 0.2-2 Mjup based on dynamical arguments of planet-disk interactions, and our proposed observations will be able to firmly detect their presence. These putative planets could become the smallest discovered beyond 10 au in any exoplanetary system. Moreover, when combined with the disc structure information, we will be able to constrain both the orbits and dynamical history of these systems. This type of systems with gapped debris disks carved by planets could be the tip of the iceberg of a larger population that ALMA is starting to reveal. Finally, focusing on debris disk systems has the advantage that we know the orientation of these systems (face-on for the proposed targets), they have a higher occurrence rate of cold directly imaged giant planets, and their disks are optically thin and thus any planet would suffer negligible extinction.
Supermassive black holes, and the outflows they drive, are an established part of our understanding of galaxy evolution. Indeed, cosmological models rely on outflows to reproduce the observed scaling relations. But the enormous range of outflow rates that are measured for AGN of the same luminosity, highlights a gaping hole in our understanding of how outflows are launched and driven. Our sample of AGN at similar distances and with similar luminosities, but with outflow rates differing by two orders of magnitude, provides the ideal opportunity to fill this gap. We will exploit the rich suite of diagnostics at 5-29um with MIRI MRS integral field spectroscopy and the sensitivity and resolution of JWST. Our analysis is built on the three cornerstones of molecular gas, ionized gas, and dust - observed together at the same resolution over the same scales, enabling us to build a holistic view of the central few hundred parsecs. From the spatially resolved kinematics we will construct geometrical models that provide a direct view of how gas is fed in from the circumnuclear disk through the obscuring torus and driven out in the outflow. We will associate the PAHs and the hot dust continuum to each of these components to test new models of the torus. And from the numerous line ratios, we will quantify the role of AGN versus stellar photoionization on the different structures. Piecing this together will enable us to highlight the physical processes that determine the prominence of the observed outflow, leading to a major advance in our understanding of the key mechanisms at the root of AGN fuelling and feedback.
In the last 15 years, the Hubble Space Telescope has spent more than four weeks worth of exposure time on a single 11 sq. arcminute region of the night sky: the Hubble Ultra Deep Field (UDF). However, deep VLT/MUSE optical integral field spectroscopy has recently revealed an abundant population of ultra-faint galaxies without counterparts in the HST imaging. These z=2.9-6.7 galaxies are detectable due to their strong Lyman-alpha emission, with equivalent widths that imply extremely young ages, small stellar masses, and a very low amount of metal enrichment. This unprecedented sample represents our best chance at studying galaxies in the earliest phases of formation, even with future JWST imaging surveys. We propose to use JWST/NIRSpec's MSA to follow-up a subset of 45-55 of these 171 galaxies at 1.7-5.1 microns in order to target strong optical emission lines: Halpha, [OIII], Hbeta, [NII], and [OII]. These observations will reveal exactly how metal-poor these galaxies are, will put direct constraints on stellar population models for young ages and low-metallicities, and, when combined with exquisite MUSE restframe-UV data, will reveal for the first time the physical conditions inside the lowest-mass star-forming galaxies at high redshift. The large wavelength coverage and sensitivity of NIRSpec are crucial for obtaining the information required to fully characterize these ultra-faint Lyman-alpha emitters.
Theoretical simulations suggest that the protoplanetary disk lifetime is dictated by the rate at which gas is eroded by photoevaporative winds created by high-energy radiation from the central star. However, photoevaporation models predict significantly different mass loss rates depending on whether the photoevaporation is driven by the EUV or X-ray radiation field. These different mass loss rates lead to different timescales for disk clearing and hence the timescale by which giant planets must form. Here we propose to observe the [Ne II] 12.8 micron and [Ne III] 15.5 micron fine structure emission lines and measure the [Ne III]-to-[Ne II] line ratio, which has been put forward as a diagnostic of the high-energy radiation field. Specifically, the ratio of these Neon lines can distinguish between EUV vs. X-ray driven photoevaporation. We propose to use MIRI to observe the Neon lines given that JWST is the only facility that can observe the [Ne III] 15.5 micron line. These observations will characterize the high-energy radiation field and thus the efficiency of photoevaporation, providing constraints on the disk clearing timescale and the planet formation timescale in protoplanetary disks.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 01678
Program Title: Calibrating Billions of SPHEREx Spectra from 2.4 to 5.0 um
Principal Investigator: Matthew Ashby
PI Institution: Smithsonian Institution Astrophysical Observatory
Col Investigators
Brendan Crill Jet Propulsion Laboratory, Michael Werner Jet Propulsion Laboratory, Gary Melnick Smithsonian Institution Astrophysical Observatory, Joseph Hora Smithsonian Institution Astrophysical Observatory

NASA's upcoming SPHEREx mission will carry out an all-sky 0.75 to 5.0 um spectroscopic survey at 6” resolution, yielding literally billions of infrared spectra of galaxies, stars, and solar system objects. This proposal seeks NIRSPEC FS spectra of four relatively bright spectrophotometric standards, to significantly reduce systematic uncertainties in the three long-wavelength SPHEREx spectral Bands from 2.4 to 5.0 um, and increase the science return from the mission. Approved JWST Cycle 1 calibration spectra are insufficient for this purpose. Our proposed NIRSPEC FS spectrophotometry will offer two key benefits. First, by cross-calibrating SPHEREx and JWST directly using standards in a brightness regime that both facilities can observe at high SNR, our proposed observations will tie the NIRSPEC calibration to billions of sources of all kinds covering the entire sky. Second, the resulting spectrophotometric calibration will enable model-free interpretations of narrow emission and absorption features in long-wavelength SPHEREx ice spectra -- features that are fundamental to its scientific mission -- greatly reducing systematic uncertainties and putting the community’s understanding of the Milky Way’s interstellar ice content on a firmer footing. Only JWST can carry out the observations proposed here.
We propose to scrutinize the puzzling tension in measurements of the Hubble constant (H0) by un-crowding observations of extragalactic Cepheids used to calibrate Type Ia supernovae (SNe Ia). The current 4-6 sigma tension between predictions of H0 based on the Early Universe (e.g., CMB+LCDM) and direct measurements from the Late Universe is one of the outstanding problems in cosmology, and Cepheid-based methods provide the strongest evidence of the tension. The unparalleled IR resolution of JWST will largely resolve the stellar backgrounds of Cepheids, whose fluctuations dominate the scatter of Period-Luminosity relations, and reduce the associated noise by nearly an order of magnitude. We propose observations of over 1500 known Cepheids in three filters and two epochs in five galaxies hosting 7 SNe Ia and in NGC 4258. The latter has a maser-based 1.5% geometric distance that will anchor a 2% measurement of H0 independent of HST and without significant background noise. These same observations will further develop two other independent distance indicators useful to calibrate SNe Ia and measure H0: the infrared TRGB and Oxygen-rich Miras. This will provide a multi-pronged approach to unravel differences between methods connecting both ends of the distance ladder and determine if the H0 tension is a robust feature of the Universe. The proposed observations are crucial to un-crowd Cepheid observations and address the only remaining systematic difference between the observations of these variables in SN Ia hosts and in the Milky Way, yielding a test of the tension beyond reproach and clearing the path for a direct 1% measurement of H0.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01701
Program Title: Dissecting the Prototypical Starbursts NGC 253 and M 82 and Their Cool Galactic Winds
Principal Investigator: Alberto Bolatto
PI Institution: University of Maryland

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Starbursts, their galactic winds, and the physical mechanisms regulating them, are key to understand the evolution of galaxies through cosmic time. We propose to use the unparalleled capabilities of JWST to perform imaging and spectroscopic observations of NGC253 and M82, the nearest archetypal examples of the starburst phenomenon and the hosts of notable starburst-driven multi-phase winds. We will obtain MIRI MRS spectroscopy of their cores and MIRI/NIRCam imaging of their multi-phase outflows. Infrared and millimeter/radio imaging have revealed the presence of super star clusters (SSCs) in both objects -- the engines of the starbursts -- the youngest of which are still in formation and highly obscured. MIRI MRS spectroscopy of these starburst regions is our best tool to study these SSCs, enabling determination of their physical conditions, stellar populations, and feedback on their surroundings. We will also obtain MIRI and NIRCam imaging to trace dust and shocks in the cool, mass-dominant component of the outflowing gas through PAHs bands and band-ratios and the [FeII] and H2 ν=1-0 transitions. At the unprecedented spatial resolution enabled by JWST, these data will reveal the details of the massive stellar clusters, the physics of the launching mechanisms of the cool wind, and the evolution of the neutral and molecular material as it is entrained by the hot galactic wind. The comparison of NGC253 (a nuclear bar-driven starburst in a large spiral galaxy) with M82 (an interaction-driven starburst in a dwarf galaxy) will allow us to characterize and compare the physics of SSC formation and wind launching in two distinctly different starburst environments.
Jets are intimately related to the process of star formation, representing the most prominent observational phenomenon during the early protostellar stage. However, little is known about their powering mechanism at the time of their formation, i.e. in embedded (Class0/I) sources, mostly due to the lack of sensitivity and angular resolution at IR wavelengths. We propose here to obtain spectral maps with MIRI and NIRSpec of the inner region of the HH46 IRS protostellar system, a well-studied, prototypical example of a jet surrounded by a cavity excavated by a wide-angle flow.

With these observations, we will probe the deeply embedded HH46 outflow engine with the same accuracy as has been achieved with HST in evolved T Tauri jets. A variety of atomic and molecular lines will be detected in the covered spectral range. They will be used to provide a full characterisation of the innermost jet structure and connect it to the wide angle flow impinging on the cavity walls. These observations will also yield insight into the other components of the system, i.e. the protostar itself and its accretion disk, providing, for the first time, a full picture of the star-disk interaction region well before planetary systems are formed.
The most luminous quasars open a window to study the physics that govern the assembly of mass at the nodes of the cosmic web at a time when the Universe was ramping up to its period of peak activity. In particular, “cosmic morning” z ~ 3–5 obscured quasars may be signposting the locations at which the most super-massive black holes were being built via the accretion of in-falling galaxies, before emerging in a blast of radiation. While long-predicted by simulations, the detection of the tidal structures that could pinpoint the dynamics of these systems is at the limit of current facilities. Deep ALMA observations of the [CII] line in the most luminous galaxy known, W2246-0526, a hyper-luminous obscured quasar at z = 4.6 surrounded by multiple neighbor galaxies, have now revealed the complex kinematics of this merger system with unparalleled detail at this epoch. Companion galaxies, tidal streams, proto-spiral arms, gas clumps and bubbles, are all resolved spatially and spectrally. However, the [CII] emission does not allow for an unambiguous characterization of the ionizing sources, as it arises from virtually every interstellar medium phase. Here we request JWST NIRSpec IFU and MIRI MRS observations of the W2246-0526 system to identify the sources of gas ionization and heating, establish whether the multi-phase [CII] gas is kinematically coupled to the purely ionized phase, and reveal the transition between the starlight-dominated spectrum of W2246-0526’s host and the hot dust continuum from the central obscured quasar. These observations will test the paradigm of galaxy-quasar feeding and feedback in this truly unique source, adding an early gem to the JWST legacy.
We propose NIRCam and MIRI imaging and MIRI MRS spectroscopy of the iconic Crab Nebula in order to test models of the progenitor and explosion mechanism by mapping the dust distribution, imaging the iron emission, measuring Ni/Fe ratios, and searching for dust compositional variations. The imaging requested will permit us to separate the bright line and synchrotron emission from dust emission and produce the first complete mapping of the dust distribution in the Crab Nebula. The [Fe II] emission will be used to study the spatial distribution of Fe in the remnant and derive its total mass. The MIRI MRS spectra will be used to measure the Ni/Fe ratios across the filaments and determine the dust composition at two positions that may have different ejecta and swept-up circumstellar contributions. These observational measurements can elucidate differences in predictions for the two competing explosion mechanisms for the Crab's progenitor (electron capture vs. Fe-core collapse) and determine whether a dense circumstellar medium, possibly distributed in a disk around the progenitor, has been important in shaping the Crab Nebula as it is observed today. The total requested time for the program is 22.57 hours.
When galactic outflows are triggered, what is the impact of feedback on the interstellar medium at the launch site? How much energy is transported into the circumnuclear regions and subsequently affect the dust geometry and metal distribution? What drives these winds and how do they depend on intrinsic AGN properties or nuclear star formation rates? Addressing these pressing questions will have a profound impact on our understanding of the role of feedback in galaxy evolution, and can only be answered observationally using high spatial- and spectral-resolution infrared instruments -- capable of peering through heavy dust screens into galactic nuclei where powerful outflows are launched -- finally made available with JWST.

Capitalizing on the unparalleled diagnostic capability MIRI exhibits over the full 5-28 micron range, our proposed MRS observations of 7 nearby luminous infrared galaxies known to host prominent shocked molecular outflows will provide a holistic view of the molecular gas, dust, AGN, star formation, and metallicity in the central 4 kpc of ongoing galaxy mergers at the scales of 30-90 pc. We will determine the heating mechanisms for and gauge energetics of the outflows, correlate their spatial properties with AGN strength, and map their influence on metal distribution and star formation in different environments spanning a range of bolometric AGN fraction, infrared luminosities, and merger class. The 4x better spectral resolution of MRS over Spitzer IRS carries discovery potential in mapping the ionization state of the outflows.

Proprietary data rights are waived to enhance the data's legacy value and to facilitate Cycle 2 proposals for the community.
Proposed Category: AR  
Scientific Category: Galaxies  
ID: 01721  
Program Title: Probing the Interstellar Medium of Galaxies in the Early Universe  
Principal Investigator: Jeyhan Kartaltepe  
PI Institution: Rochester Institute of Technology  
Col Investigators  
Anne Jaskot Williams College, Jonathan Trump University of Connecticut, Steven Finkelstein University of Texas at Austin, Ricardo Amorín Universidad de La Serena, Fuyan Bian European Southern Observatory - Chile, Denis Burgarella Laboratoire d’Astrophysique de Marseille, Mark Dickinson National Optical Astronomy Observatory, AURA, Harry Ferguson Space Telescope Science Institute, Andrea Grazian Osservatorio Astronomico di Padova, Norman Grogin Space Telescope Science Institute, Ray Lucas Space Telescope Science Institute, Pablo Arrabal Haro National Optical Astronomy Observatory, AURA, Taylor Hutchison Texas A & M University, Lisa Kewley Australian National University, Hooshang Naryeri University of California - Irvine, Casey Papovich Texas A & M University, Norbert Pirzkal Space Telescope Science Institute, Raymond Simons Space Telescope Science Institute, Rachel Somerville Rutgers University, Stephen Wilkins University of Sussex

Upon the launch of the James Webb Space Telescope, we will have the ability to probe rest-frame optical and UV emission line diagnostics from cosmic noon at $z \sim 2$ out to the epoch of reionization, free from the interference of atmospheric sky lines that have hampered observations from the ground. The Cosmic Evolution Early Release Science (CEERS) survey will provide the extragalactic community with the first opportunity to probe fundamental parameters of the interstellar medium (ISM) in a large sample of high redshift galaxies. CEERS will conduct a high redshift spectroscopic survey, including the first large spectroscopic survey of the reionization era, and will open up new optical diagnostics for $\sim 300$ high redshift galaxies, including $\sim 30$ targets at $z > 6$. With wavelength coverage of 1-5 microns, CEERS will probe [OIII] out to $z = 9$ and Halpha to $z = 6.6$, while also tracing valuable UV diagnostic lines such as [CIII] and [OIV] at the epoch of reionization. Using the full sample of CEERS star-forming galaxies, we propose to trace the evolution of metallicity, ionization parameter, and gas pressure over the history of the universe and reveal their relationships with galaxy stellar mass, star formation rate (SFR), redshift. This work will give insight into the relationship between star formation and the ISM in the early universe and the evolution of ISM properties across cosmic time.
Supernovae (SNe) play crucial roles in the chemical and dynamical evolution of galaxies; they are sources of kinetic energy and elements, and provide and destroy dust. With JWST, these fundamental questions for SNe will be tackled: How do core collapse SNe explode? How do the SN blast waves impact the ambient gas and destroy dust?

We propose to obtain high-sensitivity and high angular-resolution NIRCam images of SN 1987A, which at a distance of 50 kpc is the nearest SN explosion detected in the last 400 years. Since the explosion, the fastest part of the blast wave has overtaken the circumstellar ring, which consists of material expelled from the progenitor star when it was in a red-supergiant phase about 20,000 years ago. Deep NIRCam images, including with the [Fe II] 1.64um filter, can identify for the first time the location of the current shocked region beyond SN 1987A’s ring.

The blast wave and reverse shocks shatter and sputter dust grains into smaller fragments and collisionally heat them to high temperatures. NIRCam will be the able to spatially resolve hot dust and pinpoint the hot dust locations with respect to [Fe II]-traced shocks. Shock models including dust destruction will be used to evaluate the efficiency of the real time dust destruction by the SN blast wave.

H2 images obtained with NIRCam can resolve both the distribution and excitation of molecular hydrogen in the inner ejecta. They can trace the posited mixing of the hydrogen envelope deep into the ejecta at the time of SN explosion, thereby constraining the SN explosion model, which predicts mixing efficiencies that depend on the explosion energy.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Large Scale Structure of the Universe
ID: 01727
Program Title: COSMOS-Webb: The Webb Cosmic Origins Survey
Principal Investigator: Jeyhan Kartaltepe
PI Institution: Rochester Institute of Technology
Collaborators: Caitlin Casey University of Texas at Austin, Micaela Bagley University of Texas at Austin, Angela Bongiorno INAF, Osservatorio Astronomico di Roma, Peter Capak California Institute of Technology, Jaclyn Champagne University of Texas at Austin, Kevin Cooke University of Kansas, Olivia Cooper California Institute of Technology, Larry Davison Cosmic Dawn Center, Niels Bohr Institute, Patrick Drew University of Texas at Austin, Nicole Drakos University of California, Santa Cruz, Christopher Hayward Simons Foundation Center for Computational Astrophysics, Andreas Faisst University of California Institute of Technology, Michaela Hirschmann DARK, Niels Bohr Institute, U. of Copenhagen, Olivier Ilbert Laboratoire d'Astrophysique de Marseille, Knud Jahnke Max-Planck-Institut für Astronomie, Heidelberg, Anton Koekemoer Space Telescope Science Institute, Daizhong Liu Max Planck Institute for Extraterrestrial Physics, Arianna Long University of California - Irvine, Georgios Magdis Technical University of Denmark-DTU Space, Claudia Maraston University of Portsmouth, Crystal Martin University of California - Santa Barbara, Sinclaire Manning University of Texas at Austin, Richard Massey Durham University, Jacqueline McLeary Brown University, Henry McCracken CNRS, Institut d'Astrophysique de Paris, Hooshang Nayyeri University of California - Irvine, Alvio Renzini Osservatorio Astronomico di Padova, Jason Rhodes Jet Propulsion Laboratory, R. Rich University of California - Los Angeles, Brant Robertson California Institute of Technology, Caitlin Rose Rochester Institute of Technology, David Sanders University of Hawaii, Claudia Scarlata University of Minnesota - Twin Cities, Nicholas Scozzarella California Institute of Technology, Kartik Sheth NASA Headquarters, John Silverman University of Tokyo, Martin Spurke Universität Potsdam, Margherita Talia Università di Bologna, Sune Toft University of Copenhagen, Niels Bohr Institute, Benny Trakhtenbrot Tel Aviv University, Elena Vardoulaki Max Planck Institute for Radio Astronomy, Brittany Vanderhoof Rochester Institute of Technology, Katherine Whitaker University of Massachusetts - Amherst, Stephen Wilkins University of Sussex, Jorge Zavala Texas A&M University at Austin

We propose the COSMOS-Webb Survey, an ambitious treasury program to map a contiguous 0.6 deg^2 area with deep NIRCam imaging in 4 filters and a 0.2 deg^2 deep MIRI survey in parallel. COSMOS-Webb will accomplish the following science goals that simply cannot be done with any other existing or currently planned survey:

I) revolutionize our understanding of reionization's spatial distribution, environments, and drivers at early stages by pioneering the detection of thousands of galaxies in the epoch of reionization (EoR, z=6-11),

II) identify hundreds of the rarest quiescent galaxies in the first 2 Gyr (z > 4) to place stringent constraints on the formation of the Universe's most massive (M*>10^10Msun) galaxies, and

III) directly measure the evolution of the stellar mass to halo mass relation (SMHR) out to z~2.5 and its variance with galaxies' star formation histories and morphologies.

COSMOS-Webb is designed to leave no stone unturned for deep, wide extragalactic surveys – eliminating cosmic variance and resulting in an order of magnitude more early Universe galaxies than all other Hubble-Webb surveys combined, thus significantly constraining the shape of the bright end of the UV luminosity function and mapping the early cosmic web. It will be the primary legacy dataset from Webb for the extragalactic community by providing quick public releases of multi-band, high-resolution near-IR imaging of half a million galaxies (and an unprecedented 32,000 in the mid-IR) thus enabling innumerable legacy science projects. Conducting this next level ambitious survey now is crucial given the finite lifetime of Webb and the need to plan swift follow-up of its unique discoveries.
JWST observations of hot Jupiters promise to be spectacular. We propose a 3-5 micron NIRSpec phase curve for one of the most outstanding such targets: WASP-121b. When our NIRSpec phase curve is combined with a NIRISS GTO phase curve, it will be the richest dataset yet acquired for an exoplanet atmosphere. For the first time, we will measure an exoplanet spectrum across the full 0.8-5 micron wavelength range at all 360 degrees of circumplanetary viewing angles. This will unlock a wealth of detail on the 3D atmospheric physics and chemistry, unattainable by isolated transits and eclipses. We will track how H2O and CO abundances vary with longitude, robustly determining the atmosphere’s bulk C/O ratio and tightly constraining the role of molecular thermal dissociation. This cannot be achieved without NIRSpec, as NRISS will be relatively insensitive to carbon-bearing species. Measured variations of H2O and CO spectral bands will also give a longitudinal map of the atmosphere’s vertical thermal structure, revealing in unprecedented detail the dramatic transition from a dayside thermal inversion to a nightside that cools with altitude. Combined with existing optical data, this will allow the global balance between absorbed shortwave radiation and re-emitted longwave radiation to be determined empirically. Dynamics play a crucial role in this story, and our NIRSpec phase curve will probe wind speeds as a function of pressure, as well as the overall efficiency of day-night advective heat transport. Combining our NIRSpec phase curve with those measured by NRISS and TESS will also provide the most precise measurement of a planetary Bond albedo outside the solar system.
Proposal Category: GO
Scientific Category: Solar System Astronomy
ID: 01731
Program Title: Variability and Abundance of Hydration on M-Type Asteroid (16) Psyche: The search for water on the largest metallic asteroid
Principal Investigator: Stephanie Jarmak
PI Institution: Southwest Research Institute
CoInvestigators
Tracy Becker Southwest Research Institute, Zoe Landsman University of Central Florida, Kurt Retherford Southwest Research Institute, Chick Woodward University of Minnesota - Twin Cities, Maggie McAdam Northern Arizona University, AZ, Andrew Rivkin The Johns Hopkins University Applied Physics Laboratory, Linda Elkins-Tanton Arizona State University, Casey Honniball NASA Goddard Space Flight Center

Our current understanding of Solar System evolution hinges on interpreting the history of the asteroids. M-type asteroids in particular potentially represent the exposed cores of differentiated planetesimals, but there is insufficient data to claim with certainty that these asteroids are purely metallic. Previous detections of hydration and phyllosilicates on their surfaces further complicate the assumed composition of these asteroids. We propose to observe (16) Psyche, the prototypical M-type asteroid and target of the upcoming NASA Discovery mission 'Psyche', to quantify the amount and variability of hydration present on (16) Psyche's surface and to unambiguously determine if the hydration is a result of hydroxyl or water molecules. Our program will obtain high SNR, high spectral resolution, near to mid-IR spectra of (16) Psyche to detect and contemporaneously observe the entire 3-micron and 6-micron absorption and emission bands attributed to hydroxyl and/or water, potentially uniquely identifying water for the first time. We propose to observe (16) Psyche with a total of two visits using the NIRSpec Integral Field Unit and MIRI Medium Resolution Spectroscopy instruments to obtain spectra from two, distinct hemispherical regions and thereby measure any global variability of the hydration features. JWST’s unique capability to measure the entire 3 and 6-micron bands on the largest M-type asteroid will unambiguously identify the presence of water or hydroxyl on (16) Psyche, constraining (16) Psyche’s surface composition and impact history, providing critical context for the upcoming ‘Psyche’ mission and interpretations of hydration features observed on asteroids.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01740
Program Title: H-drop galaxies: "Rosetta Stones" at z~13 for galaxy formation studies
Principal Investigator: Yuichi Harikane
PI Institution: University College London
CoInvestigators
Akio Inoue Waseda University, Yoshinobu Fudamoto Waseda University, Takuya Hashimoto University of Tsukuba, Hiroshi Matsuo National Astronomical Observatory of Japan (NAOJ), Yoichi Tamura Nagoya University, Satoshi Yamanaka Waseda University

We propose NIRSpec/PRISM spectroscopy to confirm the Lyman break in secure candidates of luminous Lyman break galaxies at z~13. These galaxies were found in an H-band dropout selection to search for unprecedentedly high-z objects at z>12 in the 2.3 deg2 near-infrared deep imaging data in the COSMOS and UDS fields. After careful examination of non-detections in the deep optical to H-band images as well as the flat spectrum from K-band to Spitzer IRAC [3.6] and [4.5]-bands, only three candidates remain. The absolute magnitudes of these objects are typically -23.4 and the photometric redshifts are estimated to be z>12. An ALMA program targeting one of the candidates shows a tentative [OIII]88um emission line at z=13.3. The line flux is at the lower edge of the expectation, implying that this galaxy is a very low-metal system before chemical enrichment begins. A successful detection of the Lyman break from at least one object among them will yield the new redshift record far from the current ones at z=9.1 and z=11.1, and demonstrate the JWST capability for confirming galaxies at z>12. These z~13 galaxies are luminous enough to be followed-up with higher spectral resolution modes and will be "Rosetta Stones" for galaxy formation studies, once their redshifts are determined.
The importance of water in our everyday life as well as in biochemical processes on Earth is undeniable. Water is also one of the main molecular species in different astrophysical environments, such as prestellar cores, protostellar envelopes, planet-forming disks, and planetary atmospheres, and it is evidently required for the formation of life as we know it. Understanding the role of water in planet formation and the chemistry of protoplanetary disks and its delivery to rocky planets is a key requirement to understand the atmospheric composition of planets and the origins of life on Earth and, potentially, extrasolar planets.

The main goal of our proposal is to understand if water can be present in the solid state inside the snowline in planet-forming disks. Very recent laboratory experiments indicate that water ice can be trapped as part of a silicate/ice compound and thus survive in solid form beyond the sublimation temperature. A detection of trapped water and an estimation of its abundance will reinforce the wet scenario of the origin of water on Earth and terrestrial planets. A detection of silicate spectral bands will allow us to determine the silicate/trapped water mass ratio and to estimate the possible amount of water in building blocks of the planets.

An associated goal of the proposal is to search for minor bands of complex organic molecules and organic compounds to reveal the chemical complexity of planet-forming disks. These complex species may be present together with trapped water in building blocks of rocky planets inside the snowline. Their detection will critically advance our understanding of the origin of prebiotic molecules and life on Earth.
Dust is a key ingredient in galaxies, because it provides opacity, plays a key role in interstellar chemistry, and is essential for the formation of stars and (rocky) planets. Evolved Asymptotic Giant Branch (AGB) stars are an important source of stardust in galaxies. The processing of this dust in the interstellar medium (ISM) can be traced by comparing the composition of stardust to that of interstellar dust. For instance, the fraction of crystalline silicate dust in starburst galaxies is used to measure the input of fresh stardust by O-rich evolved stars in the ISM. It is unclear however in what form stardust from AGB stars enters the ISM. This is because: (1) evidence is accumulating that their winds have complex, non-spherical structures, such as disks/tori, often associated with (sub-)stellar companions; and (2) it is unclear how freshly made stardust is affected by the harsh environment that prevails in planetary nebulae (PNe), whose central stars have fast winds and extreme radiation fields. The PN NGC6302 offers a unique laboratory to study the physical and chemical processing of a dense dusty molecular torus ejected by an AGB star, which is exposed to the radiation field and stellar wind of the hottest star known in the Galaxy. Spatially unresolved observations by ISO have revealed a complex chemistry, showing emission from C-rich Polycyclic Aromatic Hydrocarbons (PAHs) in an O-rich chemistry, as well as a very profuse circumstellar dust mineralogy. Spatially resolved JWST observations will allow us to witness how the AGB ejecta are processed in the nebular environment, and to establish in what form the solids in its ejecta are delivered to the ISM.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01743
Program Title: Constraining the Atmosphere of the Terrestrial Exoplanet Gl486b

Principal Investigator: Megan Mansfield
PI Institution: University of Chicago
CoInvestigators: Jacob Bean University of Chicago, Eliza Kempton University of Maryland, Edwin Kite University of Chicago, Daniel Koll Massachusetts Institute of Technology, Matej Malik University of Maryland

JWST will provide the first opportunity to search for signs of habitability on terrestrial planets orbiting M dwarf stars. However, it is currently unknown whether planets around M dwarfs can retain atmospheres given the relatively violent history of extreme UV irradiation from their host stars. The first step to understanding the habitability of rocky planets is therefore to establish whether M dwarf terrestrial planets can retain significant atmospheres. Furthermore, terrestrial exoplanets well inside the inner edge of the habitable zone offer a chance to test theories of atmospheric evolution in a previously unexplored regime.

We propose to use MIRI/LRS secondary eclipse observations to search for the presence of an atmosphere on the terrestrial M dwarf planet Gl 486b (TOI 1827.01) and to constrain its composition. Gl 486b is the highest signal-to-noise terrestrial planet for these observations other than LHS 3844b, which has been previously observed with Spitzer and found to not possess an atmosphere. Additionally, Gl 486b has less than one quarter of the integrated XUV flux of LHS 3844b, which means it is much more likely to have retained an atmosphere. We find that with two secondary eclipse observations of Gl 486b we can determine whether or not it has an atmosphere with a surface pressure of P≥1 bar at the 5-sigma significance level. The observed spectrum will also constrain the composition of its atmosphere (if one is observed) or surface (if no atmosphere is detected) at the ≥3-sigma significance level. These observations will provide valuable data for constraining the impact of M dwarf irradiation on terrestrial planet atmospheres.
Lya observations of luminous z~8 galaxies with red Spitzer/IRAC 3.6-4.5 micron colors have resulted in significantly higher detection rates than in galaxies without such an excess or in magnitude-limited samples, despite them lying in a predominantly neutral medium. The detection of Lya in such galaxies challenges our already limited understanding of the Reionization process and is perhaps suggestive of an extreme subset of the general population, characterised by particularly efficient ionizing capabilities. However, the vast majority of such galaxies have been found in small and concentrated patches of the sky, and thus whether they are all intrinsically extreme or simply trace clustered environments remains untested. To test this theory, observations of rest-frame optical galaxy properties are necessary since Lya is sensitive to the surrounding HI and thus not a direct probe of the galaxy, while observations over large areas of the sky are a prerequisite to disentangling the combined effects of clustering and cosmic variance. We therefore propose NIRSpec/prism spectroscopy of the 10 best, bright z~8 galaxy candidates from the SuperBoRG survey, a compilation of HST imaging over 316 independent spanning an effective area of ~0.41 deg2, x2 larger than current legacy surveys. The long wavelength coverage of prism observations ensures both Lya and rest-frame optical features are simultaneously observed, allowing us to link the state of the IGM with intrinsic galaxy properties, while the (pure-)parallel nature of the SuperBoRG survey ensures we limit the effects of clustering and cosmic variance, and will provide a unique addition to upcoming ERS/GTO legacy data sets.
Ice-coated grains in protoplanetary disks provide the bulk elements critical for both the emergence of life and observable signatures of exoplanets formed in these disks, while drawing a direct line of comparison to the cold bodies in the Solar System that delivered organics to Earth. The abundance and chemical variety of these elements feeding a newborn planet depend on the radial and vertical chemical gradients of ices in disks. Vertically, the physical processes driving ice chemical evolution (grain size, dust/gas ratio, and UV flux) vary towards the disk midplane, where planets form. Radially, the temperature structure of the disk produces a series of snowlines at which different ice species sublimate. A comprehensive assay of all major ice species has never taken place for disks, let alone a direct assessment of the 2D ice gradients.

We propose to leverage the unique capabilities of JWST’s NIRSpec IFU and MIRI MRS to map such spatial variations in the ice species, relative to silicates, and in the degree of physical processing for a sample of isolated, edge-on disks. These disks are large enough to sample radially to 200 AU (<30 AU resolution) and vertically to at least 100 AU with MIRI, and a factor of 2 larger with NIRSpec. Our observations are a factor of 10 deeper than any of the 5 GTO or Ice Age ERS observations of edge-on disks and contain larger disks, allowing for mapping of even weak ice species (e.g. CH4, CH3OH, and SO2) to within the CO snowline of these systems. This program will profoundly transform our understanding of planetesimal and planetary composition in the upcoming era of exoplanet characterization and asteroid sample return missions.
Massive galaxies are excellent laboratories to test models of galaxy formation, as they represent where the key physical processes regulating galaxy growth collide as cosmic filaments intersect. Models with different physical prescriptions for galaxy growth via star-formation and negative stellar and black hole feedback make different predictions for the abundance of massive galaxies at early times (z > 6). While these models likely need very wide-field infrared surveys to come from Euclid and the Nancy Grace Roman Space Telescope to constrain their abundances, we have fortuitously uncovered an extremely massive candidate galaxy at z>10.

This galaxy, UDS-z910_18697, resides in the CANDELS UDS field. Its photometric signature and size is consistent with a galaxy at z > 10, with a stellar mass of log (M/M_☉) > 11. Such massive galaxies at these early times should be exceedingly rare in the entire observable universe, and highly unexpected to be found in the CANDELS search volume. Followup ALMA spectroscopy has uncovered a significant emission line at 293.3 GHz, consistent with [OIII] 88um at z=10.57. While this could also be other emission lines at lower redshifts, an examination of all existing data in this field and a concerted followup effort with Keck and HST continue to find z > 10 as the most plausible solution. We propose for a quick 1 hr JWST/NIRSpec prism observation, which will conclusively measure the redshift of this source and, if it is truly at z=10.57, allow the measurement of a robust stellar mass free from the blending which plagues the current IRAC observations.
## JWST Cycle 1 Abstract Catalog

**Proposal Category:** GO  
**Scientific Category:** Exoplanets and Exoplanet Formation  
**ID:** 01759  
**Program Title:** Physics and Chemistry of Planet-Forming Disks in Extreme Radiation Environments  
**Principal Investigator:** Maria Claudia Ramirez-Tannus  
**PI Institution:** Max-Planck-Institut fur Astronomie, Heidelberg  
**CoInvestigators**  

Our knowledge about the formation history of planetary systems is obtained by comparing the demographics of proto-planetary disks with the exoplanetary system population. Most of the disks that we have been able to characterize to date are located in nearby low-mass star forming regions. However, it is well known that most stars form in denser environments and therefore, it is questionable that the well studied population of planet forming disks is representative of those in which most exoplanets were assembled. Due to their large distances and high densities, so far it has been impossible to study the physical and chemical properties of proto-planetary disks in massive star-forming regions. We will exploit the unique resolution and sensitivity of JWST/MIRI to explore for the first time the impact of disk evaporation on the disk structure, warm disk chemistry, and dust mineralogy, all of which are important for planet formation models and exoplanet atmosphere composition. The derived physical and chemical properties will be compared to similar data of low-mass star forming regions of JWST GTO programmes.
We propose to obtain high-resolution NIRspec fixed slits (FS) spectroscopy and MIRI low-resolution slit spectroscopy (LRS) for newly discovered infrared-dropout X-ray sources (i.e., without any optical/NIR counterparts) in the COSMOS field. This is possibly the first population of accreting black holes, and/or heavily obscured AGNs at high redshift, providing a valuable observational constraint on a hidden phase of a significant growth of supermassive black hole (SMBH) in the early universe. Considering that our targets are optically dark, the JWST spectroscopy is the only instrument allowing to obtain the high-resolution IR spectra to detect the emission lines to confirm the spectroscopic redshift and classification for these sources. This proposed study will allow us to explore the most energetic and obscured phase of accreting black holes to understand the formation of SMBHs. Our program will facilitate the first detailed study of yet unknown heavily obscured population at early cosmic epoch.
The rate of star formation and supermassive black hole growth in galaxies has been decreasing over the last 10 billion years. This proposal aims to understand this decline by localizing and quantifying the active galactic nucleus (AGN), spatially resolving the star formation activity, and measuring the interstellar medium (ISM) conditions in eight infrared-luminous galaxies at $z \sim 0.6$. Our sample exists at a time when the cosmic star formation rate density was $>3$ times higher than locally, but when locally well-established diagnostic lines are still visible to MIRI/MRS. Mid-IR spectroscopy is a powerful way to separate the AGN and star formation energetics in galaxies, and only now with MIRI/MRS are we able to detect the rich atomic lines to quantify the black hole accretion rates ($\text{[NeV]}$, $\text{[NeVI]}$) and spatially resolve the star formation (Br-alpha) outside the local Universe. Coupling these key lines with the polycyclic aromatic hydrocarbon dust features, the warm molecular hydrogen emission lines and other key spectral features, we will establish the physical state of the ISM halfway to the peak epoch of galaxy evolution. Our program leverages existing Spitzer/IRS spectroscopy to select an optimized sample spanning the full range of star formation to AGN dominated systems. Our program will produce a valuable dataset bridging the local and high redshift Universe by testing diagnostics of the AGN, star formation and ISM conditions at intermediate redshifts so they can be extended to higher redshifts in subsequent JWST cycles.
Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 01764
Program Title: A Comprehensive JWST View of the Most Distant Quasars Deep Into the Epoch of Reionization
Principal Investigator: Xiaohui Fan
PI Institution: University of Arizona

Co-investigators
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We propose to carry out comprehensive JWST observations of the only three quasars currently known at z>7.5, deep into the epoch of reionization (EoR). Luminous quasars at the highest redshift directly probe the formation of the earliest supermassive black holes (SMBHs) in the universe, enable studies of the evolution of early massive galaxies and their connections to SMBH growth, and provide sensitive constraints on the state of the intergalactic medium (IGM) during the EoR not accessible with other probes.

We have carefully designed a JWST program to address outstanding science opportunities that EoR quasars provide, capitalizing on the transformative capabilities of JWST. By employing a combination of imaging and spectroscopic observations using NIRCam, NIRSpec, MIRI and NIRISS, our program will (1) detect the stellar continuum and nebular emission of quasar host galaxies only 680 Myr after the Big Bang, to probe host galaxy assembly and to search for signatures of outflow and feedback, (2) map the large scale quasar environment, to test quasar formation models in the context of early structure formation, (3) yield reliable estimates of the SMBH masses and constrain physical properties of the quasar broad-line regions, and (4) provide the most accurate measurement of the IGM neutral fraction at z=7.5 and detect weak metal absorption features, to map the history of reionization and IGM enrichment.

These three EoR quasars constitute the culmination of decades of searches using all-sky surveys. They are the best JWST targets for quasars at the current redshift frontier and provide the definitive reference dataset for future EoR quasar and IGM science using JWST.
We propose JWST observations of the FEAST (Feedback in Emerging extrAgalactic Star clusTers) sample. Breaking away from the Milky Way backyard, the FEAST targets are selected from the larger parent sample of Local Volume Galaxies (LVL, D<11 Mpc) and have unparalleled wavelength coverage (including HST, MUSE, ALMA). They are representative of the star formation spectrum accessible in the local Universe, with its diversity of environments (nuclear starburst vs. molecular ring, diverse arm morphologies, interacting systems, low pressure dwarf environments). NIRCam and MIRI imaging at unprecedented charted spatial resolution (~ pc) will prove to be a breakthrough for our understanding of the interplay of star formation (SF) and stellar feedback, as the Spitzer observatory was for Milky Way studies. We estimate to detect thousands of emerging clusters with masses above thousand solar mass, and sample well above the 1e4 mass limits typical of our Milky Way. The JWST-FEAST project will: 1) Probe timescales for emerging clusters as a function of cluster mass and galactic environment. We will answer the fundamental question regarding the role that cluster feedback plays in regulating the SF cycle in galaxies, necessary to constrain state-of-art detailed simulations. 2) Account for the hidden phases of SF, by mapping the tempo-morphological evolution of H II and photo-dissociated regions, and determine their relative contribution to the total emission of the star-forming region. These results will calibrate self-consistent spectral evolutionary models of stars, gas, and dust necessary to study SF in galaxies that JWST will uncover beyond the local Universe.
We propose to observe the leading and trailing hemispheres of the Uranian moons Ariel, Umbriel, Titania, and Oberon using NIRSpec IFU (G395M, 2.87 – 5.27 microns) to determine whether NH3-rich species, organics, and carbonates are present and measure CO2 ice and H2O ice features on these moons. These observations will provide an ideal opportunity to investigate the spectral evidence for past ocean world activity on these moons, assess the organic constituents on their surfaces, and measure carbon and hydrogen isotopes to assess the formation conditions in the Uranian subnebula. These science goals are highly challenging to investigate with ground-based facilities because of strong overprinting telluric bands over the 2.9 to 3.5 microns wavelength range. Furthermore, Earth’s atmosphere is opaque between 4.2 and 4.5 microns, making detection and measurement of the 4.27-micron CO2 ice band on the Uranian moons and other planetary surfaces impossible to do using ground-based facilities. JWST is therefore the only existing facility that can make these observations. We require 9.96 hours of science time, and 20.72 hours of total charged time, to make the eight observations required to complete this project’s science objectives. These observations will generate an important dataset that will inform the spectroscopic priorities of future spacecraft mission concepts that aim to explore Uranus and its moons.
We propose to measure accurate stellar masses and formation histories in the most massive halo known in the epoch of reionization, SPT0311-58 at z~6.900. The structure is anchored by the most distant dust-rich galaxies known, a pair of ultramassive merging galaxies resolved into a chaotic and clumpy rapidly-assembling structure at 0.05° resolution with ALMA. Individual 300pc-size regions within these galaxies span the gamut of galaxy properties seen in the reionization epoch from UV-luminous to totally dust-obscured. Even counting only the currently known spectroscopically-confirmed galaxies, the minimum halo mass is $\sim 10^{13}$M$_{\odot}$ just 800Myr after the Big Bang, more than an order of magnitude greater than any other overdensity found at z>6 and among the most massive halos expected over an area of thousands of square degrees. This structure offers the unique chance to understand the formation of an extreme peak in the primordial density field and the role of environment in the early evolution of massive galaxies. Using inexpensive and comprehensive NIRCam and MIRI imaging, we propose to measure accurate stellar masses and assembly histories of these galaxies on sub-kpc scales, constrain the very earliest z>10 formation history, and map out the wider environment of this benchmark system. The combination of the unique high-resolution ALMA data, very deep HST imaging, and the proposed JWST data will allow a full characterization of the stars, gas, dust, and star formation in this cosmologically important halo of primordial starburst galaxies, well into the epoch of reionization.
 gravitational lensed quasars provide an independent way to measure the Hubble constant (H0) that is crucial for assessing the current H0 tension and possible new physics beyond LCDM. The dominant source of uncertainty is the radial mass profile of the lens galaxy that cannot be constrained by lensing data alone without model assumptions. Stellar kinematic measurement of the foreground lens galaxy breaks the mass-sheet degeneracy and provides a vital mass profile constraint. We propose to observe the strongly lensed quasar RXJ1131-1231 with the NIRSpec IFU to obtain spatially resolved stellar kinematic maps of the foreground lens galaxy, that has been impossible to obtain using ground-based facilities. Given the small (~1") image separation between the multiple quasar images and the lens galaxy, the high-spatial and spectral resolution of JWST will resolve and separate the spectra of the foreground lens and the background quasar. With our proposed NIRSpec data on this one lens system alone, we will reduce the relative uncertainty on H0 from 8% to 4% in combination with our current lens sample in flat LCDM cosmology, i.e., a 100% gain in precision, with minimal mass profile assumptions. The proposed observations will further enable the study of the stellar initial mass function and dark matter distribution in the lens galaxy, and of the supermassive black hole-host connection of the gravitationally lensed background galaxy. The proposed data set of spatially resolved kinematic measurements of the lens galaxy will be a crucial step in our roadmap to obtain a 1% H0 measurement from time delays.
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 01798
Program Title: Characterizing Accretion Signatures in the Youngest Protostars: The Case of L1527 IRS
Principal Investigator: John Tobin
PI Institution: Associated Universities, Inc.

CoInvestigators
Tom Megeath University of Toledo, Leslie Looney University of Illinois at Urbana - Champaign, William Fischer Space Telescope Science Institute, Lee Hartmann University of Michigan, Patrick Sheehan Northwestern University, Nuria Calvet University of Michigan

We propose to use JWST to characterize the mode of accretion (magnetospheric or boundary layer) and its rate onto one of the nearest (d=140 pc) and best characterized Class 0 protostars, L1527 IRS. Accretion is the fundamental process of building up stellar mass and this process has not been directly characterized toward the youngest, Class 0 protostars. Accretion is typically probed using hydrogen lines, and more-evolved protostars are found to be undergoing magnetospheric accretion with their rates characterized using spectroscopy from 1 to 2.5 microns. However, direct probes of accretion onto Class 0 protostars do not currently exist because the protostars are enshrouded in dense envelopes, making them prohibitively faint for ground-based spectroscopy between 1 and 5 microns. Only JWST provides the sensitivity required to detect hydrogen recombination lines toward Class 0 protostars between 3 and 8 microns where they exhibit their brightest emission shortward of 10 microns. We will use the NIRSpec and MIRI MRS IFUs to observe the Br-alpha (4.05 microns), Pfund-alpha (7.46 microns), beta (4.65 micron), and gamma (3.74 micron) lines toward L1527 IRS. These data will provide some of the first direct evidence for the mode of accretion onto Class 0 protostars and the fraction of luminosity due to accretion in the system. Then, in conjunction with radiative transfer modeling, we will estimate the accretion rate onto the protostar using the hydrogen line luminosities, corrected for extinction using their intrinsic line ratios, estimated from accretion models.
We propose an Investigation of Protostellar Accretion (IPA) and accretion driven feedback using the NIRSPec and MIRI MRS IFUs. IPA will target 5 protostars with luminosities of 0.2 to 10,000 Lsun, stellar masses of 0.1 to 12 Msun, and distances of 150 pc to 1.6 kpc. Each shows a disk + outflow cavity morphology, is in its primary accretion phase, is deeply embedded, and requires observations at > 3 micron. Using JWSTs combination of sensitivity, angular resolution, and spectral resolution, IPA will observe each protostar in the 2.9-28 micron range and map ionic, atomic, molecular and continuum emission at spatial resolutions of 30 AU (for the lowest mass sources) to 300 AU (for the highest mass source). IPA will use spectroscopic signatures of disk accretion to measure the rate and mode of mass accretion, and measure how accretion scales with stellar mass. It will also observe shocks due to wide angle winds carving cavities into the protostellar envelopes, using the angular resolution of JWST to measure mass flow and velocity along the cavities. The combination of accretion and wind data will show how the wind properties depend on accretion. Finally, IPA will look for the effect of radiative feedback from the most massive protostar, testing models of high mass star formation that require the release of radiation along outflow cavities. In total, IPA will observe in unprecedented detail the coupled accretion and feedback that plays a central role in determining the masses of stars, providing essential inputs for cloud scale simulations of star formation and the initial mass function, and setting the stage for future surveys with JWST to enlarge the sample.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01803
Program Title: Unlocking the Mysteries of the Archetype Sub-Neptune GJ1214b with a Full-Orbit Phase Curve
Principal Investigator: Jacob Bean
PI Institution: University of Chicago
Colinvestigators
Eliza Kempton University of Maryland, Guangwei Fu University of Maryland, Peter Gao University of California - Santa Cruz, Jegug Ih University of Maryland, Tiffany Kataria Jet Propulsion Laboratory, Matej Malik University of Maryland, Megan Mansfield University of Chicago, Vivien Parmentier University of Oxford, Emily Rauscher University of Michigan, Michael Roman University of Michigan, Kevin Stevenson The Johns Hopkins University Applied Physics Laboratory, Jake Taylor University of Oxford

GJ1214b is by far the best characterized exoplanet smaller than Neptune. Yet its extensively-observed transmission spectrum has only revealed a thick layer of aerosols, which obscures the molecular features that are needed to determine the planet’s atmospheric composition. Furthermore, we still don’t know what the aerosols are made of and why the planet is so thoroughly enshrouded.

We propose to use MIRI/LRS to observe the phase curve of the sub-Neptune GJ1214b in order to unlock the mysteries of its atmosphere. In one fell swoop, our observations will measure the planet’s broadband phase curve, its phase-resolved thermal emission spectrum, and its mid-IR transmission spectrum. This program will give us first-time access to GJ1214b’s thermal emission and the part of its transmission spectrum that should be the least impacted by aerosol scattering - both uniquely enabled by JWST. We anticipate that these observations will finally reveal the composition of GJ1214b’s atmosphere and home in on the identity of its pervasive aerosols. This program will also provide the first map of a warm, sub-Neptune size planet, thus extending previous studies of atmospheric heat transport and dynamics into a new regime.

Ten years after its discovery, GJ1214b remains the highest S/N sub-Neptune size exoplanet for both transmission and thermal emission measurements. It is unlikely that a better target for investigating the nature of such planets will ever be found. These observations will therefore serve as a legacy dataset for contextualizing all previous and future studies of the ubiquitous sub-Neptune exoplanets.
The properties of galaxies in the local universe are substantially different from those measured at the peak of the cosmic star formation history, around z~2. Key questions about this evolution are still open: what physical mechanism is responsible for quenching star formation in massive galaxies? And what drives the observed evolution of the ionized gas emission? Using multi-object spectroscopy with NIRSpec, we aim to build a reference sample for the most important epoch of galaxy formation, by targeting about 150 galaxies with a uniform distribution in stellar mass ($9 < \log M/M_{\odot} < 11.5$) and redshift ($1.7 < z < 3.5$). This program will transform our understanding of both the stellar populations and the ionized gas in high-redshift galaxies thanks to the broad wavelength range, low background, and low read-out noise offered by NIRSpec. Our representative sample will provide the first census of star formation histories and metal abundances for individual massive galaxies and, together with a suite of zoom-in simulations specifically designed to match these observations, will allow us to conclusively answer long-standing questions about the nature of galaxy quenching. We will additionally characterize the interstellar medium of high-redshift galaxies by measuring the complete suite of rest-frame optical emission lines, including many that are not accessible from the ground. By connecting the properties of the ionized gas to those of the stars measured in the same galaxy population, we will finally be able to build a consistent picture of how galaxies evolved over the last 10 Gyr.
We propose to observe two z~6 quasars with NIRCam to prove the detectability of their host galaxies. High-z quasars outshine their hosts at rest frame UV/optical wavelengths. Observing the underlying host galaxy emission has eluded HST, even with advanced PSF-modelling techniques. However, detailed simulations predict that the improved resolution of JWST/NIRCam will result in successful detections of these host galaxies for the first time, with our observational strategy predicted to yield optimal detections. The two quasars selected for this pilot program were comprehensively studied with HST and ALMA, and are expected to have relatively low contrast between the quasar and host, improving detectability. The proposed pilot program will demonstrate the capability of JWST to observe high-z quasar host galaxies, and provide valuable insight into the growth of black holes and galaxies in the early Universe, and of the relationships between black holes and their host galaxies.

With these NIRCam data we will:
(a) Characterize the rest frame UV/optical SEDs of these quasar host galaxies, determining their star formation histories and dust content
(b) Determine the stellar mass of the hosts, allowing us to measure the black hole–stellar mass ratio for high-z quasars for the first time
(c) Compare the stellar (JWST) and gas (ALMA) properties of the galaxies such as their star formation rates, sizes, morphologies and masses, to see the full picture of these host galaxies
(d) Study the environments of these high-z quasars, photometrically identifying and characterizing any potential companion galaxies.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01827
Program Title: NIRSpec Integral Field Spectroscopy of LyC-Leaking Galaxies
Principal Investigator: Koki Kakiichi
PI Institution: University of California - Santa Barbara

Determining the physical nature of high redshift galaxies is key to understanding whether they were responsible for cosmic reionization. A fundamental issue is the physical conditions whereby ionizing photons can escape into the intergalactic medium. While diverse observations to redshifts z~3 have directly detected Lyman continuum (LyC) leakage from star-forming galaxies, a major puzzle is the poor correlation between the escape fraction and the ionization state of the gas inferred from nebular oxygen line ratios. Possible explanations for the scatter in this trend include the presence of clumpy internal structures of the interstellar medium, or anisotropic leakage directed through narrow channels which only occasionally align with our line of sight. We propose NIRSpec IFU spectroscopy of a carefully-selected sample of z=3 compact, metal-poor Lyman alpha emitters whose intense [O III] emission and other properties makes them ideal analogs of z>7 systems in the reionization era. By comparing spatially-resolved diagnostic line ratios with existing HST maps of the LyC radiation, and detecting diffuse H-alpha halos sensitive to the angle-averaged escape fraction, we will examine which physical processes - massive stars, faint active galactic nuclei, radiative shocks - govern the ionizing leakage and as well as its possible anisotropy. The proposed survey will provide a valuable reference sample essential for interpreting the structure and ionizing capability of reionization-era galaxies at z>6 that will be soon discovered with JWST.
Our cosmological model predicts that most of the matter in the universe is distributed in a network of filaments - the Cosmic Web - in which galaxies form and evolve. Because most of this material is very diffuse, its direct imaging has for long remained elusive, leaving many questions still open, e.g.: what are the morphological and kinematical properties of the Cosmic Web on both small (kpc) and large (Mpc) scales? How do galaxies get their gas from the Cosmic Web? Here, we tackle these questions with an innovative method to detect in emission the gaseous Cosmic Web using bright quasars as "cosmic flashlights". In particular, we propose to observe in H-alpha emission two fields at z~3 which contain the largest Cosmic Web filaments - over 4 cMpc in length - discovered so far in deep MUSE Ly-alpha emission searches around bright quasars. Because Ly-alpha is affected by radiative transfer which change both its spatial and spectral distribution, non-resonant H-alpha observations are fundamental in order to directly constrain both the filament densities and kinematics. The filament projected angular sizes are perfectly suited for NIRSpec-MOS which can trace the filaments over their full length capturing, at the same time, several embedded galaxies. Our H-alpha observations will probe structures within the filaments on scales smaller than a few physical kpc directly constraining both their density and kinematics. By relating these quantities to the kinematics and distance from associated galaxies, our result will be fundamental to informing a new generation of theoretical and numerical models in order to reveal the physics of intergalactic gas accretion and galactic outflows.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01837
Program Title: PRIMER: Public Release IMaging for Extragalactic Research
Principal Investigator: James Dunlop
PI Institution: University of Edinburgh, Institute for Astronomy
CoInvestigators:

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PRIMER (Public Release IMaging for Extragalactic Research) is a major public Treasury Program designed to provide the astronomical community with an early, large-area, homogenous, deep JWST NIRCam+MIRI imaging survey of enormous power and legacy value. Exploiting to the full the unique near-mid IR imaging capabilities of JWST, PRIMER will have an immediate scientific impact, revolutionizing our knowledge of early galaxy and black-hole formation/evolution out to the highest redshifts yet probed. Moreover, executed early in the JWST mission, PRIMER can be a key driver for maximising the exploitation of JWST in subsequent cycles, as it will yield a wealth of new high-redshift data for follow-up spectroscopy with JWST NIRSpec - we predict that PRIMER will reveal ~120,000 galaxies out to z~12, ~70% of which are new (i.e. undetected by HST or Spitzer). In addition, because PRIMER images the two key equatorial HST CANDELS Legacy Fields (COSMOS and UDS), new high-z targets will also be accessible with ALMA for follow-up at (sub)mm wavelengths, maximising the long-term impact of this major Cycle-1 program.

By delivering fully-sampled 10-band NIRCam+MIRI imaging across a wide area, PRIMER enables a wealth of extragalactic science that cannot be addressed by the approved GTO or ERS programs. Indeed, PRIMER increases by a factor of ~20 the area of comparable-quality deep JWST imaging available to the community in Cycle 1, which we show is key to advancing our knowledge of the young Universe.

To ensure the success of PRIMER we have assembled a large, expert, multi-national team. We will release all data with zero proprietary time, along with a wealth of higher-level data products.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01840
Program Title: ALMA [OIII]88um Emitters. Signpost of Early Stellar Buildup and Reionization in the Universe
Principal Investigator: Javier Alvarez-Marquez
CoInvestigators
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Despite large efforts, the nature of the sources that reionize the universe is still unknown. Imaging surveys have concluded that galaxies are detected as increasingly strong [OIII]-line emitters at high redshifts. Recent studies argue that extreme [OIII] emitters (EW[OIII]5007Å>1000Å) at redshifts above 6 should be common, and be responsible for the reionization of the universe. However, their physical properties, especially Lyman continuum emissivity, are not firmly established yet. We here propose a set of NIRCam imaging and NIRSpec integral-field spectroscopy for a complete sample of LAEs/LBGs at redshifts above 6 identified as [OIII]88um emitters with ALMA. These data will establish i) the age and mass of the stellar population, ii) the structure of the stellar population and ionized gas nebula, iii) the physical conditions, kinematics and ionization status of the ISM, and iv) the LyC escape fraction. The combinations of JWST’s deep and high-angular resolution multi-wavelength imaging and spectroscopy, in conjunction with ancillary ALMA data, will provide key information on the early stellar mass and galaxy assembly in the EoR, and the relevance of [OIII]88um emitters in the reionization of the universe.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01843
Program Title: Cloud composition and origin of the reddest known sub-stellar companion HD 206893 B
Principal Investigator: Jens Kammerer
PI Institution: European Southern Observatory - Germany

JWST will open up a new parameter space for studying exoplanet atmospheres in the near- and mid-infrared beyond ~3 microns. The reddest known sub-stellar companion HD 206893 B represents an important and extreme test case for atmospheric models of exoplanets and brown dwarfs, and its unusual color sets constraints on the cloud composition and dust parameters which such models need to predict. Currently, no atmospheric model can predict the extremely red color of HD 206893 B. We aim to study the composition and size distribution of the dust grains causing the red color of HD 206893 B. Moreover, we aim to constrain the C/O abundance ratio of HD 206893 B, which will in turn unravel its formation history and resolve the current uncertainty about its age and mass. Located at an angular separation of ~200 mas from its host star and with a contrast of ~7.5-8.5 mag, we identify aperture masking interferometry with NIRISS as the only way to study this companion at ~4-5 microns with sufficient precision to discriminate dust grain properties and constrain its C/O abundance. L- and M-band observations with JWST are key for understanding the nature of HD 206893 B's atmosphere and the formation history of this enigmatic object. Ultimately, these observations will provide a benchmark test for improving atmospheric models of very cloudy and dusty sub-stellar objects and increase the reliability of such models in the ~4-5 microns regime which is hardly accessible from the ground.
Rocky planets orbiting close to M-dwarf stars are among the most common planets known in the Galaxy. While many of these worlds have similar masses and radii to the Solar System terrestrial planets, they may have vastly different geology due to their short-period orbits. Here we propose to observationally constrain the past and present geology of the hot rocky exoplanet LHS 3844b by measuring its thermal emission spectrum with MIRI/LRS. Recent Spitzer observations of this planet indicate that it is most likely a bare rock, inviting detailed study of the surface. Our proposed emission spectrum will tightly constrain the surface fractions of different types of rock, including basalt (expected from volcanism akin to present-day Earth), ultramafic rock (expected from a solidified magma ocean or high-temperature volcanism), and granite (an indicator of crustal reprocessing). Our data will also be highly sensitive to trace amounts of sulfur dioxide that could arise from ongoing volcanic outgassing (> 3sigma detection of 100 parts per million sulfur dioxide in 0.01 bar atmosphere). Together, these measurements will provide the first empirical constraints on the geologic history of a rocky exoplanet orbiting an M-dwarf.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 01854
Program Title: It’s COMplicated: Disentangling the formation pathways of complex organic molecules from molecular clouds to comets.

Principal Investigator: Melissa McClure
PI Institution: Sterrewacht Leiden
Co-investigators
Harold Linnartz Universiteit Leiden, Sergio Ioppolo Queen Mary University of London, Marina Rachid Laboratory for Astrophysics-Leiden Observatory, Danna Qasim NASA Goddard Space Flight Center, Jennifer Noble Aix Marseille Universite, Maria Drozdovskaya Center for Space and Habitability, Universitat Bern, Daniel Harsono Academia Sinica, Institute of Astronomy and Astrophysics, Helen Fraser Open University, Martin Corder NASA Goddard Space Flight Center, Valentine Wakelam Universite de Bordeaux, Jacqueline Keane University of Hawaii, Ewine Van Dishoeck Universiteit Leiden, Edwin Bergin University of Michigan, Merel van ’t Hoff University of Michigan, Yvonne Pendleton NASA Ames Research Center, Belen Mate Instituto de Estructura de la Materia, Abraham Boogert University of Hawaii, Serena Viti Sterrewacht Leiden, Paola Caselli Max-Planck-Institut fur extraterrestrische Physik, Maria Elisabetta Palumbo INAF, Osservatorio Astrofisico di Catania, Brett McGuire Massachusetts Institute of Technology, Thanja Lamberts Universiteit Leiden, Will Robson Rocha , Herma Cuppen Radboud Universiteit Nijmegen, Jeroen Terwisscha van Scheltinga Sterrewacht Leiden

Complex organic molecules (COMs), the chemical building blocks from which pre-biotic molecules can arise, must form on icy dust grains within cold molecular clouds, where their gas-phase sublimation products have been extensively studied with millimeter telescopes."Non-energetically" processed cloud COMs may be thermally and energetically reprocessed within protostellar envelopes, either further increasing their complexity or potentially destroying them before they enter the comet-forming regions of protoplanetary disks. However, to date no COMs more complex than methanol have been conclusively detected in the solid state.

We propose to test whether energetic reprocessing COMs during the protostellar stage of star formation substantially enhances the ice chemical complexity over that of cold molecular cores by obtaining R=2700-3200 spectra from 3-15um along six lines of sight to ice-rich regions characterized by non-energetic, thermal, and energetic ice processing. These spectra will reveal and disentangle overlapping signatures of >4 specific COM species (acetaldehyde, ethanol, dimethyl ether, and methyl formate), which are suggested by previous 5-sigma absorption features at 3-7% of the continuum near 7.2um with Spitzer, guaranteeing a robust detection of the separate features. If the complexity of COMs is already high enough within our non-energetic targets, then it means that every star system formed from those clouds could come pre-seeded with the partially assembled ingredients for life. If we still detect COMs in the highly energetically processed targets, then we can gauge how much and what variety of species survive the journey from cloud to comet-forming disk.
Supernovae (SNe) Type IIn are known for their bright mid-IR luminosities and large dust masses. Inferred masses of newly formed SN dust can inform our understanding of the origin of dust in the high redshift Universe, particularly at the Epoch of Reionization. Pre-existing dust offers an independent measurement of the circumstellar medium (CSM) and, therefore, the pre-SN mass-loss history of the Type IIn progenitors, which remain largely unknown. The origin and heating mechanism of the dust, however, remains mostly ambiguous since a majority of the Spitzer observations contain only 3.6/4.5 micron photometry, which is insufficient to identify multiple dust components, detect colder (<500 K) dust reservoirs, and measure the dust composition. Unlike most other SN subclasses, SNe IIn dust (both newly formed and pre-existing) tends to remain radiatively heated by ongoing CSM shock interaction for years post-explosion, so that it will be warm enough (>200 K) to be detected by JWST. Here we propose MIRI/MRS spectroscopy of five well-studied SNe IIn from the Spitzer era that span a range of epochs (5-40 years) to constrain the origin, mass, and heating mechanism of dust in these systems. Cycle 1 is critical for these observations given the growing gap in time since their most recent Spitzer detection. No other telescopes, including SOFIA and ALMA, can make measurements of such dust in other extragalactic SNe due to sensitivity. Given the relative brightness of SNe IIn, we can complete this sample in 12.36 hours (including overhead).
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 01863
Program Title: Confirming the First Low-Metallicity Wolf-Rayet Dust Factory
Principal Investigator: Ryan Lau
PI Institution: ISAS, Japan Aerospace Exploration Agency

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In our current understanding of dust-forming sources, we cannot account for the observed quantities of dust in local and high-redshift galaxies. Recent studies indicate that the answer to this long-standing mystery may include carbon-rich Wolf-Rayet (WC) stars. Theoretical models predict that WC stars can even be significant sources of dust at sub-solar metallicity, consistent with the lower metallicity environment of galaxies beyond the local Universe. However, there is a dearth of known dust-forming WC binaries at sub-solar metallicity to verify the model predictions.

New results from the Spitzer Space Telescope have identified an IR-luminous outburst named SPIRITS 19q, which exhibited highly efficient dust production likely linked to a dust-formation episode from an extragalactic WC system in the subsolar metallicity outskirts of the nearby galaxy NGC 2403. This tentative link between SPIRITS 19q and the WC star has not yet been confirmed due to the unresolved nature of the luminous stellar cluster coincident with 19q. In this proposal, we request 6.74 hours of spectroscopic imaging observations with the NIRSpec IFU between 0.6 - 5.3 microns at R ~ 100 in order to confirm dust formation from the WC star by spatially resolving and identifying the near-IR (1 - 2 micron) spectroscopic features associated with the WC star and the mid-IR (3 - 5 micron) emission associated with the SPIRITS 19q. Efficient dust-formation from just one WC system can have a significant impact on the ISM, and confirmation of efficient dust formation from this WC star would validate the theoretical models that demonstrate WC stars as significant sources of dust at sub-solar metallicity.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01864
Program Title: The Formation of a Primeval Hyperstarburst Galaxy at z~6
Principal Investigator: Kedar Phadke
PI Institution: University of Illinois at Urbana - Champaign
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The most massive galaxies in the universe formed in intense dust-enshrouded bursts very early in the history of the universe. These early gas- and dust-rich starbursts have awaited the sensitivity, resolution, and wavelength coverage of JWST for decades. We propose a comprehensive imaging and IFU spectroscopic study of the SPT0346-52 compact hyperstarburst galaxy at z=5.7. With an astounding 3000Msun/yr of star formation packed into a r~0.6kpc region and no sign of an AGN, this system is uniquely compact and intense among all known high-z galaxies. Our observations will finally detect the stellar emission from this extreme galaxy, dissect the physical conditions of the HII regions, and probe for an AGN from a novel angle for high-z dust-enshrouded systems. These data will place this system in the larger context of massive galaxy formation and enable unprecedented detail in our understanding of a primeval massive starburst.
The amount of dust outside of galaxies, inferred from reddening measurements of background quasars and galaxies by foreground galaxy halos, is comparable to that within galaxies, but the origin of this dust is uncertain. Numerical simulations suggest that galactic winds, driven by stellar or SMBH processes, are the primary source of the enriched circumgalactic medium (CGM), but the direct detection of dust in a galactic wind on the relevant CGM scale remains elusive. The recently discovered 100-kpc (>20 r_stellar) wind in Makani, a massive galaxy at z = 0.459, is an excellent target to test this idea. The cooler neutral-atomic and molecular gas phases in this wind coexist with the warm ionized gas out to distances of 20 kpc but apparently not beyond. This provides tantalizing evidence that we are witnessing, for the first time on CGM scale, the dissolution of the outflowing cool clouds into the warm ionized phase as predicted by theory. Our proposed MIRI/NIRCam multi-band imaging of the warm dust and molecular gas in Makani will fill the temperature gap between the warm ionized gas and cool molecular/neutral-atomic material and capture this critical phase transition. This program takes advantage of a remarkable coincidence between several key spectral features of Makani and the bandpasses of the MIRI/NIRCam filters. These data will allow us to (1) determine whether dust grains experience evolution as they travel to large distances from the host galaxy, (2) assess the impact of the dynamic CGM on the processing of the warm H_2 molecules in the wind, and (3) provide a holistic view of the dust-H_2 cycle in forming galaxy-CGM ecosystems which will inform future modeling.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 01869
Program Title: LyC22 - Deep spectroscopic insights on star-forming galaxies 2.2 Gyr after the Big Bang
Principal Investigator: Daniel Schaefer
PI Institution: Observatoire de Geneve
Collaborators:
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We propose the LyC22 survey, a reference survey at z~3, to provide deep rest-optical spectra of Lyman continuum (LyC) emitting galaxies and comparison samples at 2.2 Gyr after the Big Bang.

The proposed NIRSpec observations will provide a full spectral coverage over ~2800-6800 Ang rest-frame, including the major indicators of LyC escape, which have recently been established from studies at low-z. The full suite of faint optical emission lines will be used to test the indirect LyC indicators, determine ISM properties (density, temperature, abundances), and constrain the ionizing radiation field of LyC emitters, LyC non-emitters, and other star-forming galaxies at z~3. The observations will also allow us to examine a possible redshift evolution of these properties.

Such a reference survey is uniquely possible at z~3, where the largest number of LyC emitters beyond z~0.4 is currently known. It is also the closest one can get to the epoch of reionization and obtain precision measurements of the LyC, the far-UV stellar and interstellar - already secured - and nebular spectra of the same galaxies with JWST. Such data are essential to obtain a consistent picture of stellar populations, the UV radiation field, abundances, and ISM properties of galaxies. Most importantly, understanding indirect LyC indicators at high-z is crucial since direct LyC detections are fundamentally not possible in the epoch of reionization.

The LyC22 survey targets two fields selected from major high-z Lyman continuum surveys undertaken with Keck, Subaru and HST. It will obtain more than 200 deep spectra of z~3 star-forming galaxies, including 29 with known LyC emission or firm upper limits.
Proposal Category: GO
Scientific Category: Large Scale Structure of the Universe
ID: 01871
Program Title: The First Observations of the Ionizing Luminosity of Galaxies within the Epoch of Reionization
Principal Investigator: John Chisholm
PI Institution: University of Texas at Austin
CoInvestigators

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The first galaxies changed cosmic history by emitting sufficient ionizing photons to ionize all the gas between galaxies. This cosmic reionization changed the thermal history of intergalactic gas, quenched early star formation, and set the seeds of the large-scale structure in the present universe. While theory underscores the importance of reionization, observations have yet to determine how reionization occurred. Hubble Space Telescope observations suggest that star-forming galaxies may have supplied the ionizing photons, but it is not clear whether they originated in rare massive galaxies or more common low-mass galaxies. Observations must constrain the sources of cosmic reionization. For the first time, the James Webb Space Telescope can open the window onto empirical constraints of the sources of reionization. Here, we propose 22.2 hours of charged time for a NIRSpec MOS configuration focused on the GOODS-North footprint. HST, Spitzer, and Keck have revealed compelling candidates for sources of ionizing photons within this field. We propose deep G235H and G395H observations to observe Mg II, [O II], [Ne III], [O III], and Balmer emission lines in up to 15 galaxies within the epoch of reionization. We will use well-tested methods to estimate the escape fraction of ionizing photons from these galaxies using the Mg II doublet and Balmer decrement. Additionally, the extinction-corrected Balmer emission will estimate the production of ionizing photons. Combined, this will be the first measurement of the ionizing luminosity during the epoch of reionization, and stringently test whether bright and/or faint galaxies emitted enough ionizing photons to reionize the universe.
Our understanding of magnetic activity in low-mass stars and brown dwarfs was revolutionised by the discovery of brown dwarf "pulsars", with pulsed radio emission caused by massively scaled-up analogs of Jupiter's aurorae. These discoveries showed that the transition to planet-like magnetospheres occurs at the end of the stellar main sequence.

The brown dwarf pulsars all show optical/NIR variability. It is claimed that this is causally linked to the radio emission and probably caused by the impact of auroral electrons on the brown dwarf atmosphere. These auroral electrons may therefore have a profound impact on the atmosphere; altering the opacity, providing local heating, destroying dust clouds and triggering pre-biotic chemistry in the brown dwarfs. Since aurora are expected on exoplanets, similar effects may be in play.

The claim that the radio aurora cause the optical/NIR variability in brown dwarf pulsars is yet to be established. In particular, a model that claims elevated H- opacity is the driver needs to be rigorously tested. Here we propose JWST spectrophotometry of a benchmark brown dwarf pulsar that we will use to understand the mechanism by which auroral electrons induce optical/NIR variability.
We propose JWST/MIRI medium resolution spectroscopic observations of the multi-phase outflow in ESO 420-G13 to obtain: i) the mass and the energy budget for both the ionized and the molecular wind components; ii) the first IR-based determination of the chemical abundances and the metal-loading factor in a AGN-driven outflow. The mass and the energy budget will then be compared with current AGN feedback simulations, to determine the role of the ionized wind in the acceleration and dispersion of the molecular gas and the origin of the outflowing material. IR-based metallicities in the outflow of ESO 420-G13 can provide the first direct evidence of whether AGN-driven outflows regulate the content of heavy elements in galaxies. Chemical abundances based on IR transitions are insensitive to the dust obscuration and the temperature effects that introduce serious biases in stratified and inhomogeneous nebulae, conditions that are expected when a strong galactic wind is present. This study will provide unique insight into the feedback processes in low-luminosity AGN, the most common form of activity in the nearby Universe. ESO 420-G13 represents one of the two cases where a radio-elusive jet has been revealed through its interaction with the ISM, and the only one where the ionized phase of the outflow has been revealed in the [NeII] 12.8 micron emission line, distinguishing this source as an ideal laboratory to study the supermassive black hole-ISM interaction with JWST.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01879
Program Title: Opening the era of direct metallicity measurements in high redshift galaxies
Principal Investigator: Mirko Curti
PI Institution: University of Cambridge
Co-investigators
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We propose to obtain “direct”, electron temperature (Te)-based metallicity measurements at the cosmic noon (1.6<z<3) by means of deep (40 hours on source) observations with the NIRSpec Micro-shutter assembly (MSA) of a sample of ~60 galaxies within the COSMOS field, aimed at detecting the elusive [O III]4363 and [S II] 4069 auroral lines. The leap in sensitivity provided by JWST compared to 10-meters class ground-based telescopes will finally open the era of systematic, unbiased detections of metallicity-sensitive auroral lines at high redshift, representing an unprecedented improvement over currently available datasets. This measurements will provide the key to break many of the degeneracies afflicting the physical interpretation of high redshift galaxy spectra. By simultaneously targeting auroral and strong nebular lines (i.e. [O II]3727, [O III]5007, [N II]6585, [S II]6718,32), we will be able to derive accurate calibrations for strong-line metallicity diagnostics. Calibrations tailored to the high-redshift Universe are necessary to correctly interpret the cosmic evolution of metallicity scaling relations, as probed by current and future surveys. Our exceptionally deep spectroscopy will also allow the study of other weak spectroscopic features, including broad wings in high S/N, high spectral resolution nebular line profiles tracing galactic winds, and detailed studies of the attenuation law by using multiple Balmer lines (Ha, Hbeta, Hgamma, Hdelta).
The evolution of galaxy metallicities over cosmic time encodes the key processes encompassed in the physics of baryon cycling. NIRSpec on JWST will transform our understanding of galaxy metallicities at z>2 via the routine detection of strong (rest frame optical) nebular emission lines. And yet, there is substantial evidence that our current strong line metallicity indicators that have been calibrated for physical conditions at z=0 do not apply at high redshift. We propose to develop the most advanced theoretical strong line metallicity calibrations to date in an effort to aid the interpretation of the vast suite of near infrared emission lines that will be detected by JWST. Our models will derive the physical conditions of high redshift galaxies from modern cosmological simulations, and compute, for the first time ever, their expected emission line signal from a diverse range of sources. Our simulations include emission from HII regions on a particle by particle basis, AGN, and diffuse ionized gas, and will investigate the impact of non Solar abundance patterns, rotating stars, and binary stars on nebular emission lines. These proposed models will significantly advance theoretical strong line calibrations from the single zone photoionization models that are the current status quo, and bring metallicity indicators into the modern era.
Proposal Category: GO
Scientific Category: Galaxies
ID: 01893
Program Title: Galaxy assembly at z > 6: unraveling the origin of the spatial offset between the UV and FIR emission
Principal Investigator: Stefano Carniani
PI Institution: Scuola Normale Superiore, Pisa
CoInvestigators

Exploring galaxies in the first Gyr of the Universe, at z>6, is the key to understanding the galaxy assembly process. For many galaxies at z>6, ALMA observations revealed that the far-infrared (FIR) [CII] and [DIII] lines are completely consistent with systemic redshift of the galaxies, but spatially offset by several kpc from the rest-frame UV region. The physical origin of these spatial offsets is still debated and depends mainly on the galaxy and interstellar medium (ISM) properties. We therefore propose JWST/NIRSpec observations in IFU mode to obtain spatially resolved spectra of three star-forming galaxies at z=6.6-8.2. The selected targets display the clearest spatial offsets between the rest-frame UV and the FIR lines among all high-z star-forming galaxies observed with ALMA so far, which makes them a unique sample for understanding the nature of this displacement. Our proposed NIRSpec observations are designed to obtain an accurate measurement of the spectral energy distribution in the rest-frame UV and optical band at the location of both FIR line emission and UV regions. This will allow us to both investigate the properties of the ISM (gas metallicity, ionisation parameter, dust obscuration) and unveil the possible presence of satellite galaxies associated with the displaced FIR emission, thus providing key constraints to galaxy assembling models at the re-ionisation epoch.
Revealing the dramatic build-up of galaxies during the first 1 billion years to the peak of star formation at z~2-3 is one of Hubble's greatest achievements. Yet huge gaps in our understanding remain since our galaxy samples are incomplete due to the uncertainties of photometric selection. The highly-incomplete spectroscopic information at z>6 means that we lack physical understanding of the processes driving early galaxy assembly. To date, less than 1% of known galaxies in the epoch of reionization at z>6 have confirmed redshifts, and basic quantities such as mass-to-light ratios can be uncertain by factors of 5-10 — due to the unknown contributions of strong emission lines in the photometry used to derive stellar masses. As a result, we still only have a broad, phenomenological picture of early galaxy formation and growth. FRESO exploits JWST's remarkable new spectroscopic capabilities to remedy this situation in a maximally-efficient way. By obtaining 2 hr deep NIRCam/grism observations with just the F444W filter, FRESO will yield redshifts over a wide redshift range for a complete sample of ~330 z~7-9 galaxies, as well as ~1200 z~5-6.5 galaxies, in the Deep CANDELS areas of the GOODS-S and GOODS-N fields. FRESO will yield an unprecedented Legacy archive, for the first time, of spectroscopic redshifts and emission line measurements from [OIII]+H-beta, H-alpha, and even Pa-alpha at low redshifts. FRESO's grism observations provide the total line fluxes for estimating galaxy stellar mass and critically-needed slit-loss calibrations of NIRSpec/MSA spectra. We are not requesting proprietary time to ensure that FRESO will be a key Legacy dataset for the community.
Comets are primitive remnants of solar system formation, cryogenically “preserved” in the outer solar system for the last 4.5 Gyr and retaining a record of the volatile and refractory material incorporated into their nuclei from the protosolar nebula. Systematically characterizing the composition of comets is necessary to understand the formation and evolution of the solar system, the presence of life on Earth, and the development of other young planetary systems. This program will measure the insoluble organic matter (IOM) and polycyclic aromatic hydrocarbon (PAH) content of 9P in its inner coma, thereby providing clues to the heritage and potential processing of its refractory organics. This study can only be performed with JWST owing to its sensitivity to faint extended emission, its spectral resolving power, and complete spectral coverage of the near- and mid-infrared. Discerning the nature of cometary refractory organics will directly address the Planetary Science objective of NASA’s 2020-2024 Vision for Scientific Excellence: advance scientific knowledge of the origin and history of the solar system and the potential for life elsewhere. This JWST spectroscopic study addresses fundamental questions in our understanding of the refractory organics in cometary material and the formation of the solar system. It affords the first opportunity to sample the complete infrared spectrum of cometary refractory organics, and represents a chance to test the limits of the JWST discovery space that complements cometary missions’ in situ and sample analyses, thereby improving our understanding of the origins and evolution of the solar system.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01902
Program Title: High resolution, high contrast kernel phase imaging with NIRCam
Principal Investigator: Jens Kammerer
PI Institution: European Southern Observatory - Germany
CoInvestigators
Laurent Pueyo Space Telescope Science Institute, Anand Sivaramakrishnan Space Telescope Science Institute, Marshall Perrin Space Telescope Science Institute, Benjamin Pope New York University, Frantz Martinache Observatoire de la Cote d'Azur, Steph Sallum University of California - Irvine, Andrew Skemer University of California - Santa Cruz

JWST offers excellent sensitivity, but its mirror size and therefore its angular resolution are constrained by the limited space in the Ariane V payload fairing. For this reason, super-resolution imaging is of particular interest to JWST and an aperture mask has been installed for this purpose inside the NIRISS instrument. In the past few years, kernel phase interferometry has been developed as a viable advancement to aperture masking. Kernel phase is a post-processing technique for full pupil images that achieves similar resolution than aperture masking (down to 0.5 lambda/D) and is particularly suitable for space-borne telescopes. Since kernel phase does not need a physical mask that blocks ~85% of the light to be placed in the pupil plane, it achieves higher throughput and therefore higher efficiency. Here, we propose to calibrate the kernel phase technique for the NIRCam instrument, since the impact of an increased angular resolution will be most powerful at the shortest wavelengths. Kernel phase interferometry will expand the parameter space accessible by JWST and give rise to high-contrast, high-resolution imaging such as the direct detection of forming giant planets or imaging of circumstellar outflows and nebulosities.
The aim of this proposal is to extend our understanding of the environmental effects on the evolution of protoplanetary disks, the formation of planets, and the formation of brown dwarfs, for the first time, to the starburst regime. The large distances to starburst clusters make the JWST the only instrument (for a long time to come) capable of providing the required high spatial resolution and sensitivity in bands where disk emission is prominent. Besides, starburst environments are rare in our Galaxy today, but they are common in the early Universe, star forming and merging galaxies. We thus ask NIRCAM and MIRI observations of the 3-5 Myrs old starburst clusters Westerlund 1 in a set of wide and narrow filters, in order to: 1) select stars with disks from color-color and color-magnitude diagrams; 2) study disks properties from the analysis of their Spectral Energy Distributions, accretion from NIRCAM narrow band images, and the dust population in disks from MIRI observations; 3) correlate the spatial variation of the disk fraction and the average disk properties with local UV fields and stellar density, in order to assess the effects of the environment on disks evolution and dispersal; 4) Derive the IMF down to the brown dwarf regime and compare it with other clusters with different environments in order to understand if the low-mass end of the IMF is affected by the starburst environments.
A wealth of new theoretical and observational evidence supports now the idea that episodic accretion is a fundamental and common phenomenon across mass and time in star formation. In particular, the most recent discovery and follow-up of four accretion bursts from massive young stellar objects (MYSOs) have been key to link low- and high-mass star-formation mechanisms to the common ground of disk-mediated accretion. Two of the events (dubbed NIR-dark accretion bursts) from early stage and highly embedded MYSOs could not be detected below 10 micron, hampering our ability to infer the key accretion parameters of these bursts. Only JWST gives us the unique combination of spatial resolution (to obtain the source spectral energy distribution - SED - clean from extended emission and source multiplicity, typical of massive star forming regions) and sensitivity in the thermal IR for line spectroscopy of these faint IR massive protostars. We propose a ToO multi-epoch program with NIRSpect and MIRI-MRS to study and follow-up the next NIR-dark accretion burst in the 3-28 micron regime. For the first time, we will catch an accretion burst from an early-stage MYSO during its rise, heralded by methanol maser flares. We will derive its key accretion parameters (rising time, duration, released energy, strength, accreted mass, accretion luminosity and mass accretion rate), its origin, as well as its impact on the source and its surrounding environment (chemistry, ice/gas state of disk/envelope, ejection burst). This ToO will finally prove the nature of accretion bursts from early-stage MYSOs, conclusively linking low- and high-mass star-formation mechanisms across mass and time.
The observation, down to a few parsec scale, of individual Population III star-forming complexes and Globular Cluster Precursors (GCPs) and their interaction with the hosting galaxy and environment, necessarily requires strong gravitational lensing amplification. Moreover, the role of such low luminosity (M1500 > -16) sources on the ionization of the surrounding medium is a key factor in our understanding of the cosmic reionization. We propose JWST/NIRSpec-IFU mode to map two key targets (dubbed LYA and POPIII) amplified by the Hubble Frontier Field galaxy cluster MACS J0416, currently the modeled lens with the richest number of confirmed multiple images (>180).

LYA is a strong Ly-alpha emitter (rest-frame equivalent width, EW>200A) at z=6.149 in which at least 10 star-forming knots of (<)10-100 parsec sizes and intrinsic ultraviolet magnitudes m1500=29-33 are secured with VLT/MUSE and HST deep observations and recognized as the ionizing sources.

POPIII is a much fainter Ly-alpha arclet straddling the caustic at z=6.629 with a barely detected HST counterpart down to mag1500>~31 (observed), implying an intrinsic m1500>~35. The huge Ly-alpha EW of the Pop III arclet (>1000A rest-frame) suggests the presence of a metal-free star complex.

JWST will be a game-changer for the challenge of understanding the nature of such extremely faint and compact ionizing sources. We will blindly map, at tens of parsec scale, the key optical lines like [OIII]4959-5007 and H-alpha, and definitely identify the targets as GCPs, quantify their ionizing photon production efficiency in an unprecedented low-luminosity regime and rich environment at the tail end of the Cosmic Reionization epoch.
We propose to use MIRI to search for planets around four white dwarf stars to test whether giant planets drive the mysterious metal pollution observed in the atmospheres of many white dwarf stars. Giant planets are believed to throw planetesimals into the white dwarf where they are torn apart and accreted onto the photosphere. The low planet-star contrast makes the planet light detectable in these systems without the use of a coronagraph. We will search for both resolved companions, and an infrared flux excess from unresolved companions. We chose the nearest (10–22 pc) and youngest (0.8–2.7 Gyr) targets to ensure that we probe down to sub-Jovian masses around these evolved stars. Unlike the one transiting candidate found by Vanderburg et al. (2020), any white dwarf planet we discover will likely have formed beyond the ice line and may be more representative of giant planets found in our own solar system. With our sample, if no planets are found, we will be able to all but rule-out the favored model for how the metals are accreting onto the white dwarf star. Conversely any planets we do find will open a window to studying exoplanets beyond the ice-line.
We propose the Assembly of Ultradeep Rest-optical Observations Revealing Astrophysics (AURORA) program, which will obtain ultra-deep and continuous R=1000 NIRSpec MSA spectroscopy over the wavelength range 1-5 microns using the G140M/F100LP, G235M/F170LP, G395M/F290LP gratings. We will collect spectra of ~100 galaxies in two carefully chosen pointings, one in each of the COSMOS and GOODS-N extragalactic legacy fields. Target selection will be optimized to obtain the first statistical sample of ~45 z=1.5-4.0 galaxies with detectable auroral emission lines enabling direct oxygen abundance estimates. With these measurements, representing an order-of-magnitude increase in the sample of direct oxygen abundances at z~1.5, we will construct the first empirical strong-line metallicity calibrations at high redshift. Such calibrations are essential for exploiting the transformative rest-frame optical emission-line datasets to be collected with JWST/NIRspec out to z~10, and measuring actual oxygen abundances rather than simply the ratios of strong nebular emission lines. In turn, measurements of galaxy chemical abundances over cosmic time, in concert with their stellar masses, provide critical constraints on galaxy formation models. Using the proposed ultra-deep near-IR spectroscopic observations, we will also explore the physical properties of gas and stars in z>6 star-forming galaxies during the epoch of reionization, calibrate the nebular attenuation curve during the epoch of peak star formation (z=1.5-4.0), and constrain the formation histories of massive, quiescent galaxies.
Winds powered by radiation from active galactic nuclei (AGN) are thought to critically affect galaxy evolution. The fate of molecular gas in such outflows is one of the most important unsolved questions in galaxy evolution: if we find that winds can entrain, reheat or remove molecular gas from galaxies we will prove that AGN can quench star formation in its host galaxy and enable the first studies of this key stage of AGN feedback. However, despite years of searches with ground-based telescopes, only a few molecular outflows are known among AGN in the local universe. Here we propose MIRI and NIRSpec IFU observations to spatially resolve the molecular gas kinematics in the three most promising hosts of strong molecular outflows identified from Spitzer and SDSS spectroscopy. These observations will be used in a detailed investigation to reveal if the molecular gas demonstrates the kinematics commensurate with the wind hypothesis. Furthermore, the JWST data will allow the first in-depth studies of the impact of the AGN on the molecular gas in their hosts.
Identifying the sources that drove cosmic reionization is a key goal of observational cosmology. Photons from these sources carved out ionized bubbles in the neutral intergalactic medium, and these bubbles gradually coalesced, resulting in a fully ionized Universe.

The luminous z=6.6 'COLA1' galaxy lies in the epoch of reionization and shows a remarkable, double-peaked Lyman-alpha (Lyα) line, the only one confirmed by multiple teams with high SNR and resolution. The detection of Lyα flux bluewards of the systemic velocity means COLA1 resides in an ionized bubble. The exact velocity at which the blue Lyα light is cut-off constrains the bubble size. This bubble provides a unique fortuitous, controlled environment -- since the bubble size is constrained, so is the total ionizing flux required to power it. Did COLA1 produce this ionizing flux all by itself? Or is it surrounded by large numbers of bright galaxies? Is a significant contribution from the faintest galaxies necessary?

We propose to blindly identify emission-line galaxies within the ionized bubble and to obtain sensitive spectroscopy of COLA1 itself with slitless grism spectroscopy in the NIRCam F356W filter. The bubble size is well matched to the effective field of view for H-beta and the [OIII] doublet at z=6.6. We will obtain spectroscopic redshifts for all objects brighter than 0.1 L* (SFR>2 Msun/yr) and directly measure their ionizing photon production rate. We will then assess how much contribution from unseen galaxies is required. Through our detailed accounting of ionizing photons we will address the central question to reionization studies: was it bright or faint galaxies that reionized the universe?
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01935
Program Title: Unshrouding the Sub-Neptune Population: The Case of TOI-421b
Principal Investigator: Eliza Kempton
PI Institution: University of Maryland
Co Investigators:
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Sub-Neptunes, while ubiquitous in our galaxy, remain of uncertain disposition. The radius distribution of such planets indicates they have rocky cores with tenuous primordial H2-rich atmospheres, but their bulk densities admit the possibility of ice-rich compositions. Only atmospheric investigations can break degeneracies in bulk composition and address the fundamental nature of the sub-Neptune population. However, observations of sub-Neptunes have repeatedly returned featureless or muted transmission spectra that have provided us with little information about their atmospheres. It is strongly suspected that photochemical haze is to blame for the muted spectra. Such hazes are predicted to form over a limited temperature range — primarily below 850 K. The implication is that planets hotter than this cutoff temperature should be free of obscuring hazes and should present clear atmospheres that are ideal for atmospheric investigations. To that end, we propose to obtain the transmission spectrum of TOI-421b — the highest S/N sub-Neptune that is hot enough (T_{eq}~1,000 K) to expect haze-free conditions. We will measure the transmission spectrum of this planet from 0.83 to 5 microns, allowing us to determine the abundances of multiple H/O/C-bearing molecules. Our results are expected to provide the first clear-atmosphere characterization of a sub-Neptune. We will robustly constrain the bulk composition of TOI-421b’s atmosphere, test theories of aerosol formation, and provide valuable context for how to best use JWST for future investigations of the sub-Neptune population.
Gravitational wave and optical/infrared detections of the binary neutron star merger GW170817/AT2017gfo revealed the astrophysical site of heavy element production via rapid neutron capture (the r-process). Emission from a "kilonova" powered by the radioactive decay of these elements was used to infer the bulk abundances of r-process species and a handful of lighter elements in its outer layers, but we still have no "smoking gun" evidence that any specific heavy elements, especially lanthanides (Z>57), were produced in the ejecta. Moreover, our observations were confined to the earliest stages of kilonova evolution when most of the ejecta were optically thick, obscuring any emission from the inner layers. With only a single well-studied kilonova, there is significant progress to be made once the LIGO/Virgo/KAGRA gravitational wave detectors begin finding new neutron star mergers during their Observing Run 4. Here we propose to use the unique sensitivity and mid-infrared capabilities of JWST/NIRSpec to observe one kilonova at >30 days post-merger over three epochs with non-disruptive triggers. Detailed observations of even a single kilonova would lend new insight into the r-process, enabling us to isolate emission features from specific r-process species (especially Nd) in the "nebular" phase of kilonova evolution when they are mostly transparent to mid-infrared radiation. From these measurements, we will begin to probe the unique physical conditions and variations in kilonova abundance patterns, taking the next step forward in our understanding of the r-process.
Studies of the Galactic Center routinely deliver breakthrough discoveries. However, our picture is far from complete. Webb is uniquely poised to answer a number of remaining questions including: (1) How do stars form so close to the super-massive black hole (SMBH) and do they have an unusual initial mass function? (2) Are the old stars missing or have they been tidally stripped, making them faint and hard to detect? (3) How are binary systems, including those with compact objects, created, destroyed, and merged around a SMBH? and (4) Is there a cusp of dark matter and stellar mass black holes around the SMBH? To address these questions, we require a thorough and accurate census of the different populations of stars within the nuclear star cluster, including spectral types and 3D kinematics. We propose to obtain NIRCam imaging of the central 2' (4.8 pc) and NIRSpec IFU spectroscopy of the central 9" (0.36 pc) in order to study the nuclear star cluster and its co-evolution with the SMBH.
Core-collapse supernovae (SNe) are among the most influential phenomena in the universe, and yet many key questions about their nature and explosive products remain unanswered. This uncertainty has broad implications for the formation and evolution of stellar populations, the metal enrichment of galaxies, and the origin of life. JWST opens new pathways to investigate SNe, and this proposal outlines an interdisciplinary science-enabling survey of the young SN remnant that provides the clearest access to the properties of a core-collapse SN: Cassiopeia A (Cas A). Three critical questions motivate a suite of observations made up of imaging mosaics covering the entire main shell and IFU spectroscopy of select representative locations: What is the total mass, relative chemical yield, and kinematic distribution of various components of the SN ejecta? How much ejecta is transformed into dust and how much of that dust survives passage through the reverse shock? What processes govern the formation and final fate of the remnant compact object? The requested observations exploit JWST’s unique ability to 1) provide maps of shocked and unshocked ejecta that can be directly compared to current SN models; 2) constrain the grain size distribution, clump size, and density contrast of shocked SN dust; and 3) peer deeply enough through high extinction to test hypotheses about the nature of Cas A’s central compact object, which is regarded as a key object to understanding neutron star evolution models. The proposed program will serve as an invaluable resource for subsequent JWST cycles and will contribute to the legacy of prior NASA Great Observatories that have all observed Cas A.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01952
Program Title: Determining the Atmospheric Composition of the Super-Earth 55 Cancri e
Principal Investigator: Renyu Hu
PI Institution: Jet Propulsion Laboratory
Co-investigators: Alexis Brandeker Stockholm University, Mario Damiano Jet Propulsion Laboratory, Brice-Olivier Demory University of Bern, Diana Dragomir University of New Mexico, Yuichi Ito University College London (UCL), Heather Knutson California Institute of Technology, Yamia Miguel Universiteit Leiden, Michael Zhang California Institute of Technology

One of the primary inquiries of astronomy is to determine for small exoplanets (1) whether they have an atmosphere, and (2) what their atmospheres are made of. To date, we have answered the first question for only one planet that is rocky in composition and lacking an H2-dominated atmosphere (i.e., a super-Earth): 55 Cancri e. Here we propose to use JWST’s spectral capabilities in the mid-infrared to answer the second question for this planet. Prior observations with Spitzer photometry showed that the planet must have either a thick volatile-rich atmosphere, or a molten lava surface shrouded by a mineral atmosphere while rotating at an asynchronous rate. The Spitzer measurements also ruled out H2O, CO, or CO2 as the main component of the atmosphere. The remaining possibility for the volatile-rich atmosphere are either an O2 atmosphere formed by the loss of hydrogen from a primordial water world, or an N2 atmosphere with varied abundances of CO2, CO, and HCN resulted from the accretion of rocky materials. The mineral atmosphere would otherwise be dominated by Na, O, K, Fe, and SiO. We request the JWST time to observe two secondary eclipses of 55 Cancri e, one with NIRCam using the F444W filter and the other with MIRI/LRS in the slitless mode. These observations will be able to distinguish the thick atmosphere scenario versus the mineral atmosphere scenario at high significance via spectral features of H2O, CO, CO2, and SiO. The proposed observations would provide the first direct detection of a non-H2-dominated atmosphere on an exoplanet and demonstrate JWST’s unique capability to characterize super-Earths in thermal emission.
Several planet-mass companions (PMCs) on wide-orbits have been imaged around young stars (1-10 Myr). Their estimated mass is just around the brown dwarf to giant planet transition (~13 Jupiter masses), which makes them especially interesting for both star and planet formation theories. Several formation scenarios exist, but none of them can explain all properties of the currently known PMCs. There are strong theoretical reasons to expect disks around PMCs, and indirect evidence for disks around PMCs from optical and near-infrared emission exists. However, attempts to detect the dust and gas emission of the disk directly have been unsuccessful. The high sensitivity of JWST MIRI will allow detecting disks with sizes smaller than one au, masses as low 1/10000 of a Jupiter mass and will provide first constraints on the solid and gas composition of disks around PMCs. We propose to observe the PMC CT Cha b with the MIRI spectrograph to detect the dust and gas emission (water lines) of its disk. Those results allow for a comparison to the composition of the primary disk of CT Cha, which is observed simultaneously, and to observations of protoplanetary disks, providing new constraints for possible differences in disk evolution. Those observations, together with forthcoming complementary ALMA observations, will put stringent limits on the mass and size of the companion's disk; quantities most relevant for PMC formation theories and spin-evolution studies. The proposed program will be a big step forward for our understanding of the mysterious nature of wide-orbit planet-mass companions and will serve as a pioneering study for future JWST surveys of PMCs.
An unsolved problem in the context of the chemical composition of star-forming regions is how complex organic molecules (COMs) are produced. The current consensus is that such molecules are formed in ice mantles on dust grain and then released to the gas-phase upon heating or irradiation by photons or cosmic-rays. However, while a wealth of COMs has been detected in the gas-phase toward hot cores and hot coronas with millimeter/submillimeter observations, only methanol, the precursor of some COMs, has been securely identified in the ice phase. Laboratory experiments have shown that large molecules are formed in the ice-phase, thus suggesting that interstellar ices hold large reservoirs of COMs.

With this proposal, we aim to answer: (i) What is the origin of COMs in ices and their abundances? (ii) How does the external UV irradiation of OB stars affects the formation of COMs in protostellar cores? and (iii) How do COM abundances depend on the ice structure (amorphous and crystalline)? We propose mid-infrared observations with MIRI/MRS toward six protostars located in the Ophiuchus Molecular Cloud and close to two OB stars, S1 and HD147889. The resolution (R~2500) and sensitivity (S/N > 300) provided by MIRI will allow us to identify and resolve narrow spectral bands associated with COMs, such as acetaldehyde and ethanol. They can be formed from energetic processing of methanol ice with UV photons and cosmic rays. In particular, ethanol is a precursor of glycolaldehyde, a building block of amino acids. Additionally, the IFU spectroscopy will allow us to map the distribution of ices around the YSOs and establish correlations with the environment (e.g., UV irradiation field).
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 01960
Program Title: The JWST Protostellar Ice Legacy Survey
Principal Investigator: Ewine Van Dishoeck
PI Institution: Universiteit Leiden
ColInvestigators

This proposal requests NIRSpec-IFU G395H R=2700 observations at 2.87-5.27 micron of 15 low-mass protostellar targets (23 sources) that will be observed with MIRI-MRS in GTO time. Short integration PRISM or G23SH integrations are added to cover the shortest wavelengths. Together, the data provide full 2-28 micron spectra that will allow a complete inventory of interstellar ices in the material that feeds young disks in their planet-building phase. The NIRSpec range contains unique features of CN- and S-containing molecules, as well as the prominent solid and gaseous (13)CO2 and (13)CO bands that constrain the chemistry and thermal history of the sources. By observing a significant sample of protostars at high S/N in different evolutionary stages with both NIRSpec and MIRI, we provide a JWST legacy that can be used to investigate trends in abundances and abundance ratios of major and minor C, O, N and S species on spatial scales from >1 pc down to <100 au. Moreover, the high spatial resolution of NIRSpec allows spectral maps of the stronger ice features on ~20 au scales. By matching abundances with what ALMA observes in their hot cores we can address directly the debate whether gas-phase abundances reflect thermal sublimation of ices or whether additional gas-phase chemistry plays a role. Ultimately our protostellar ice inventory can be compared with ices observed in mature edge-on disks to assess chemical inheritance versus evolution and reset of the planet-building material.
The driver and timeline of the reionization of hydrogen in the early Universe remains a major uncertainty in galaxy formation. As redshift increases, one of the primary observational tracers of ionizing photons, Lyman-alpha (Lyα), is attenuated by the increasingly neutral intergalactic medium. In order to circumvent this and understand the production and escape of ionizing photons at the highest redshifts, we propose a novel and efficient JWST imaging survey in the UDF to target H-alpha (Ha) and the UV continuum at z=5.4-6.6 (the tail end of reionization epoch). These medium-band observations (NIRCam F182M, F210M, F430M, F460M, F480M; and NIRISS F430M & F480M in parallel) build on the deepest HST and MUSE data publicly available anywhere. The existing data provide Lyα and some UV information at high spatial resolution, but lack the critical constraints on the intrinsic ionizing photon production and dust geometry within such galaxies. Our joint Lyα-UV-Ha analysis will provide this information on global and spatially resolved (kpc) scales for the first time in individual, normal star forming galaxies during reionization. This program enables the first unbiased accounting of the ionizing photon production budget via Ha, pinpointing where Lyα is initially created, and resolving the uncertainties in current data from galaxy orientation and dust geometry. The proposed data also enable multiple additional science objectives, including the discovery of [OIII]+H-beta emitters at z=7.6 -9.3. These data will be public immediately, enabling numerous rapid follow-up studies with JWST, and will enhance the legacy value of past and future surveys in this popular field.
The evolution in the mass accretion rate and density of supermassive black holes (SMBHs) shows that the SMBHs in today's most massive galaxies formed in a relatively short time after the Big Bang. This biased growth of massive galaxies and SMBHs requires rapid accretion in the early Universe, coupled with a strong influence of SMBH activity on the hosts through powerful radio jets and radiation-driven winds. Luminous radio galaxies offer ideal laboratories for studying both modes of AGN ‘feedback’ and where the AGN does not outshine its host galaxy (unlike for quasars). With the NIRSpec/IFU it is now possible for the first time to spatially resolve the impact of AGN radio jets on their host galaxies in the rest-frame optical at $z > 4$.

We will target the rest-frame optical emission of two of the most distant, prototypical radio galaxies, TN J1338-1942 ($z=4.11$) and TGSS J1530+1049 ($z=5.72$). We will spatially resolve the ionization state, kinematics and metallicity of the gas to constrain how AGN with large-scale radio jets inject energy and modify star-formation in the presence of infall and AGN- and starburst-driven winds. The data will also constrain the stellar populations, delineate the host galaxy morphologies, and detect broad emission lines in scattered light to derive black hole masses. Both objects will be observed with NIRCam in GTO to study their larger Mpc-scale environments. Together these programs will allow us to derive a complete picture of the evolution of some of the most massive and powerful radio AGN known in the early universe, from their energetic cores to their wider cosmic environments.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 01967
Program Title: A Complete Census of Supermassive Black Holes and Host Galaxies at z=6
Principal Investigator: Masafusa Onoue
PI Institution: Max Planck Institute for Astronomy

Yoshiki Matsuoka Ehime University, Takuma Izumi National Astronomical Observatory of Japan (NAOJ), John Silverman University of Tokyo, Xuheng Ding Institute for Physics and Mathematics of the Universe, Michael Strauss Princeton University, Nobunari Kashikawa University of Tokyo, Department of Astronomy, Tohru Nagao Ehime University, Masayuki Akiyama Tohoku University, Astronomical Institute, Masatoshi Imanishi National Astronomical Observatory of Japan (NAOJ), Melanie Habouzit Max-Planck-Institut für Astronomie, Heidelberg, Marta Volonteri CNRS, Institut d’Astrophysique de Paris, Anna-Christina Eilers Massachusetts Institute of Technology, Jan-Torge Schindler Max Planck Institute for Astronomy, Roderik Overzier Observatorio Nacional, Alessandro Lupi Universita degli Studi di Milano-Bicocca, Zoltan Haiman Columbia University in the City of New York, Sarah Bosman Max Planck Institute for Astronomy, Victor Marian Max-Planck-Institut für Astronomie, Heidelberg, Benny Trakhtenbrot Tel Aviv University, Rebekka Bieri Max-Planck-Institut für Astrophysik, Maxime Trebitsch Max Planck Institute for Astronomy, Malte Schramm National Astronomical Observatory of Japan (NAOJ), Kazuhiro Shimasaku University of Tokyo, Graduate School of Science, Seiji Fujimoto Cosmic Dawn Center, Niels Bohr Institute, Irham Andika Max-Planck-Institut für Astronomie, Heidelberg, Feige Wang University of Arizona, Jinyi Yang University of Arizona, Jianwei Lyu University of Arizona, Marianne Vestergaard University of Copenhagen, Niels Bohr Institute, Kohei Inayoshi Peking University, Hideki Umehata RIKEN Wako Institute, Shunsuke Baba National Astronomical Observatory of Japan (NAOJ), Chen-Hsiu Lee NSF’s NOIRLab, Kentaro Aoki National Astronomical Observatory of Japan (NAOJ), Yoshihiro Kawaguchi Ōnomichi City University, Bram Venemans Max-Planck-Institut für Astronomie, Heidelberg, Fabian Walter Max-Planck-Institut für Astronomie, Heidelberg, wangqi he National Astronomical Observatory of Japan (NAOJ), Knud Jahnke Max-Planck-Institut für Astronomie, Heidelberg, Kotaro Kohno University of Tokyo, Institute of Astronomy, Satoshi Kikuta University of Tsukuba

We propose NIRSpec Fixed-Slit + NIRCam broad-band observations of 12 of the lowest-luminosity quasars known at z=6 to obtain the first full census of the black holes and host galaxies of the earliest quasars. We will derive the well-calibrated Hbeta-based masses (M_BH) of supermassive black holes (SMBHs) with NIRSpec’s G395M grism, from which we characterize the distribution functions of M_BH and Eddington ratios, eliminating severe previous selection biases due to the limitation of ground-based NIR spectroscopy. We will measure their host stellar masses with NIRCam’s F150W and F356W filters to calculate the SMBH-to-stellar mass ratios, from which we investigate the origin of the tight correlation between M_BH and host bulge mass observed in the present-day universe. Our sample size will allow us to stringently determine whether SMBHs have grown in parallel with their hosts (as suggested by recent ALMA observations), or if one evolves faster than the other. Our sample is the least biased of all high-z quasar samples, allowing us to derive a comprehensive picture of the SMBHs and their host galaxies within the first billion years of the universe.
Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 01970
Program Title: Zooming into the monster’s mouth: tracing feedback from their hosts to circumgalactic medium in z=3.5 radio-loud AGN
Principal Investigator: Wuji Wang
PI Institution: ARI Heidelberg University
Col Investigators: Dominika Wylezalek Zentrum fur Astronomie - Universitat Heidelberg, Carlos De Breuck European Southern Observatory - Germany, Joel Vernet European Southern Observatory - Germany, Nicole Nesvadba Observatoire de la Cote d’Azur, Matthew Lehner CNRS, Institut d’Astrophysique de Paris, David Rupke Rhodes College, Daniel Stern Jet Propulsion Laboratory, Nadia Zakamska The Johns Hopkins University, Andrey Vayner The Johns Hopkins University

Actively accreting supermassive black holes (AGN) can have significant impact on the evolution of their host galaxies through feedback in the form of gas winds and radio jets which can be seen on kpc scale, encompassing the entire galaxy. We propose here to determine the impact of powerful AGN on their host galaxies at Cosmic Noon where the co-moving density of luminous AGN is at its peak. Our sample consists of high-redshift radio galaxies (HzRGs), the only AGN population, in which quasar-mode feedback, radio-mode feedback and the host galaxies can be characterised simultaneously. We will use the JWST to “zoom into” some of the most massive and active galaxies at the onset of the peak of star-formation and AGN activity to address the long-standing question on how exactly AGN-driven outflows propagate into the host galaxy and how small-scale phenomena close to the central engine reflect on the large-scale jet and gas characteristics. The diffraction-limited resolution of JWST and two-dimensional coverage with NIRSpec IFU will provide a 10-fold improvement in resolution over existing observations and will allow us to map the stellar, gas, and excitation components of distant HzRGs all at once for the first time. It is critically important to compare local AGN with what happens near the start of the peak of the cosmic star formation rate density at comparable sub-kpc scale resolution, and with exactly the same diagnostics. Our sample at the “sweet spot” redshift ~3.5 is uniquely suited to do this, covering the critical wavelength regime between [OII] and H-alpha even including [SII] in just one spectral setting with the NIRSpec G235H/F170LP.
Proposal Category: AR
Scientific Category: Exoplanets and Exoplanet Formation
ID: 01977
Program Title: Glows in the Dark: New Models for the Atmospheric Structure and Evolution of High Metallicity and Low Mass Giant Planets
Principal Investigator: Mark Marley
PI Institution: NASA Ames Research Center

CoInvestigators
Caroline Morley University of Texas at Austin, Roxana Lupu Bay Area Environmental Research Institute, Natasha Batalha NASA Ames Research Center, Jonathan Fortney University of California - Santa Cruz

JWST is expected to discover a host of young, self-luminous, low mass giants planets in the coming years. The telescope will be capable of detecting planets comparable to our own Uranus and Neptune when they were young and glowing brightly in the thermal infrared. The atmospheric structure and evolution models that are needed to interpret these planets and place them in context, however, do not currently exist or are not adequate for the job of characterizing these expected discoveries. We propose to develop grids of exoplanet atmospheric structure, spectra, and evolution models to lower masses and higher metallicities than have yet been computed. Such models will facilitate the planning and interpretation of future observations of cool, low mass directly imaged planets by JWST. We will deliver our grids and the infrastructure needed to understand and manipulate them to the community as a resource to support the study of young giant planets into the future.
Globular clusters (GCs) are the oldest objects in the Universe for which accurate ages can be determined. They are ideal laboratories because, to first approximation, they consist of stars of the same age, distance, and chemical composition. Stellar color-magnitude diagrams (CMDs) of GCs are important tools for stellar astrophysics and dynamics.

We propose to use JWST in direct-imaging mode with NIRCam and NIRISS to obtain high-precision photometry and astrometry of the faintest objects in the two closest GCs: M4 and NGC6397. Our program is two-fold:

1) We intend to map the transition in the CMD and in the luminosity function between stars fusing Hydrogen and non-fusing brown dwarfs (BDs). Observations of GC BDs are crucial for testing and calibrating metal-poor models of BD atmospheres, formation and evolution.

2) We will also be sensitive to the entire white dwarf (WD) cooling sequence in the infrared. This will extend existing HST photometry, allowing us to probe fundamental astrophysics and search for evidence in the colours of hotter WDs for (or against) the existence of ancient planetary systems from the presence (or not) of IR excesses.

Understanding field contamination in GC observations is fundamental, and the proposed program will be used to test JWST’s astrometric capabilities by determining proper-motion membership of target sources using existing high-resolution HST images that just reach the star/BD limit, 15 yrs ago. Future JWST epochs will allow us to extend proper-motion membership to fainter objects and well into the BD sequence.
Proposal Category: GO  
Scientific Category: Exoplanets and Exoplanet Formation  
ID: 01981  
Program Title: Tell Me How I'm Supposed To Breathe With No Air: Measuring the Prevalence and Diversity of M-Dwarf Planet Atmospheres  
Principal Investigator: Kevin Stevenson  
PI Institution: The Johns Hopkins University Applied Physics Laboratory  
Co-investigators:  
Jacob Lustig-Yaeger The Johns Hopkins University Applied Physics Laboratory, Munazza Alam Harvard University, Natasha Batalha NASA Ames Research Center, Mercedes Lopez-Morales Smithsonian Institution Astrophysical Observatory, Joshua Lothringer The Johns Hopkins University, Ryan MacDonald Cornell University, Erin May The Johns Hopkins University Applied Physics Laboratory, Sarah Moran The Johns Hopkins University, Sarah Peacock University of Arizona, Zafar Rustamkulov The Johns Hopkins University, David Sing The Johns Hopkins University, Kristin Sotzen The Johns Hopkins University Applied Physics Laboratory, Jeff Valenti Space Telescope Science Institute, Hannah Wakeford University of Bristol

One of JWST’s four pillars of science points to finding the building blocks of life elsewhere in the universe. Planets orbiting M-dwarf stars represent our best (and only) opportunity to measure the spectrum of a potentially-habitable planet in the next decade. The quest towards habitability begins with a simple question: Does this planet have an atmosphere? Whether or not terrestrial M-dwarf planets can retain their atmospheres is a hotly debated topic and only a large observational campaign acquiring exoplanet transmission spectra can provide unequivocal evidence of atmospheres. Understanding which M-dwarf planets have atmospheres will focus future theoretical efforts and could provide the first evidence of a “cosmic shoreline”, a universal division between planets with and without substantial atmospheres. Even the population of planets with tenuous atmospheres will inform us about atmospheric escape processes.

In this study, we will obtain transmission spectra of nine terrestrial planets orbiting the nearest M dwarfs using instrument modes that are sensitive to CO2 at 4.3 microns and CH4 at 3.3 microns, the strongest such features in JWST’s wavelength range. Upon successful completion of this campaign, we will know which transiting M-dwarf planets within 15 parsecs have atmospheres and, of those that do, the fundamental diversity in their basic atmospheric compositions. We will know how the presence of an atmosphere correlates with planet irradiation and escape velocity, and how the evolutionary history of M dwarfs shapes the atmospheres of the planets that orbit them. Ultimately, this study will generate new sparks of life in M-dwarf planet research.
Intermediate mass black holes (IMBHs) in local low metallicity dwarf galaxies, with masses between one hundred and a million solar masses are crucial to our understanding of the origins of supermassive black holes (SMBHs) and will give rise to the prime targets for LISA. Despite their importance, very little is known about their mass distribution and the host galaxies in which they reside. Dynamical studies cannot uncover the lowest masses, and accreting IMBHs have eluded detection by optical spectroscopic, mid-infrared color, X-ray, and radio surveys due either to obscuration of the central engine, or dilution of the accretion activity from star formation in the host galaxy. In fact, there is currently no direct evidence for black holes with masses between ~ 150 - 10,000 solar masses, a gap of roughly two orders of magnitude in mass. In this pilot program, we propose to push the frontier in the low mass regime by observing two nearby low mass, low metallicity dwarf galaxies with the most convincing evidence yet for optically elusive AGNs in the lowest mass galaxies. Using the NIRSpec IFU, this pilot program is designed to unveil a ~1000 solar mass IMBH, an order of magnitude lower than any other nuclear black hole known in a galaxy thus far and will be the lowest mass galaxy in the Universe known to host an AGN. With a modest investment in observing time, this study can not only make a breakthrough in the IMBH mass frontier, but pave the way to discover more elusive AGNs in the low mass regime. This program can only be carried out using the unique capabilities of JWST.
The joint gravitational wave and electromagnetic detections of the binary neutron star (BNS) merger GW170817 ushered in a new era of astrophysics. In the UV/optical/NIR the emission (a “kilonova”) was powered by radioactive decay of nuclei produced via r-process nucleosynthesis. In the gamma-ray, X-ray, and radio the emission was instead powered by an off-axis jet typical of short gamma-ray bursts (SGRBs); this connection was previously supported by the HST detection of a kilonova in the short GRB130603B. With only a single joint GW-EM detection and a single kilonova detection in an SGRB, the key frontier is to begin to map the distribution of merger outcomes: ejecta mass, velocity, geometry, and nucleosynthetic yields. Here we propose to achieve this goal with detailed JWST observations of a kilonova associated with an SGRB; observations of kilonovae in SGRBs are essential because the orientation is well known (face-on, along the binary's angular momentum axis) and the LIGO/Virgo Observing Run 3 did not yield any new joint GW-EM detections. Such a detailed study can only be achieved at the redshifts typical of SGRBs with the infrared sensitivity and angular resolution of JWST. We request up to 11.9 hours for 1 SGRB event. The JWST observations will be supported by an on-going multi-wavelength program (e.g., Chandra, VLA, ALMA, Gemini, Keck, Magellan, MMT) that will provide the target, cover optical and early NIR follow-up to establish the baseline behavior, and complete the multi-wavelength picture of the event. Given the broad interest in this topic we waive the proprietary period.
Abstract

Some of the most extreme galaxy nuclei lie within our cosmic backyard. Compact Obscured Nuclei (CONs)—with sizes of tens of parsecs, luminosity densities in excess of $10^8$ Lsun $/pc^2$, and gas column densities $>10^2$ cm$^{-2}$—have recently been identified in local infrared-luminous galaxies. The physical properties, power source (AGN vs star formation), and fate of these nuclei remains unclear. The rich diagnostic power of the mid-infrared, combined with the sensitivity and resolution of JWST, are crucial to understanding the CONs. A signpost of CONs is their (sub)millimeter emission from vibrationally excited HCN molecules. We propose JWST observations of two prototypical CONs—NGC 4418 and IC 860. We will observe the 14um absorption of HCN and measure the physical conditions inside the CONs. We will also use the JWST observations to measure the molecular gas properties (via H2 emission and CO absorption) and infer the dust grain properties and radiation field in and around the CONs. The compactness and energy densities of the CONs imply that they are be powered either by black hole accretion or by star formation with an extremely top-heavy (i.e., O star only) initial mass function. Their column densities render optical and X-ray diagnostics ineffective— the spectroscopic capabilities of JWST are crucial to detecting any emission from highly ionized species (e.g., [Ne V], [Ne VI], [Si IX]) arising from ionized radiation leaking out of the CON. This modest time investment will reveal the physical conditions, energy source, and fate of some of the most extreme galaxy nuclei known.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Large Scale Structure of the Universe
ID: 01995
Program Title: Answering the Most Important Problem in Cosmology Today: Is the Tension in the Hubble Constant Real?
Principal Investigator: Wendy Freedman
PI Institution: University of Chicago
CoInvestigators: Barry Madore Carnegie Institution of Washington, In Sung Jang University of Chicago, Abigail Lee University of Chicago, Kayla Owens University of Chicago, Taylor Hoyt University of Chicago

Measurements of the Hubble constant are on the cusp of heralding in a fundamental discovery in cosmology that goes beyond the standard Lambda CDM model. Yet published differences in the local distance scale may be indicating that systematic errors, which have long been the bane of the extragalactic distance scale, are larger than currently estimated. The importance of this possibility cannot be overstated. Independent paths for measuring $H_0$ are vital to provide necessary cross checks against unrecognized systematic uncertainties. In this first year of JWST, we propose to measure the distances to half of the current sample of SHoES galaxies that calibrate the Type Ia supernova distance scale using three independent methods in the same galaxies: this will be the first time such a test has been carried out. Each of these methods (Cepheids, the TRGB and carbon stars) are individually of high precision. With its unequalled light-gathering power in space, its infrared sensitivity and high angular resolution, JWST is uniquely poised to provide the most accurate local measurement of the Hubble constant yet to date; and most importantly, it will provide a robust estimate of its systematic uncertainties (currently reddening, metallicity and crowding/blending). As part of its legacy, HST resolved the factor-of-two debate in the Hubble constant, but even with two additional decades of progress, outstanding uncertainties still remain. A legacy of JWST will be the resolution of the current tension, and a robust answer to this question: "Is there new physics required beyond the standard model?"
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02001
Program Title: Mineral clouds in the atmosphere of the hot Jupiter HD189733b
Principal Investigator: Michiel Min
PI Institution: Space Research Organization Netherlands

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Hot Jupiters are gas giant planets in short period, tidally locked orbits. Their properties offer a unique opportunity to study the composition of the gas and clouds in their atmospheres, which carry crucial information on their formation history. We propose to use JWST/MIRI in LRS mode for a detailed characterization of the aerosols in the atmosphere of HD189733b, one of the best studied, prototypical cloudy hot Jupiters. We will (1) establish the presence and composition of theoretically predicted mineral clouds, and (2) determine for the first time the chemical composition of the atmosphere by consistently including gas and clouds. This will constrain the formation history of HD189733b. Models for gas giant planet formation predict large variations in elemental abundances of the atmosphere resulting from accretion of pebbles and planetesimals. Cloud properties depend critically on this chemistry, and strongly impact the observable atmosphere. The MIRI instrument on board JWST offers for the first time access to the mid-infrared wavelength range for exoplanet studies, crucial for mineral cloud characterization. HD189733b has many advantages for the study of mineralogical clouds: 1) detailed studies have convincingly shown that clouds and/or hazes are present in the upper atmosphere, but their nature is not constrained, 2) from a theoretical perspective the temperature structure of the planet is ideal for hosting mineral clouds, 3) the exquisite observational properties of HD189733b and superb sensitivity of JWST allow us to even address day/night asymmetries in its atmosphere using a various parts of a single transit observation.
We propose MIRI MRS observations of the nearby galaxy IC5063 that will enable us to determine the changes in the H2 gas properties that occur as radio jets propagate through a disk and initiate outflows. We will map the emission of H2 lines in order to derive the temperature, the density, and thus the pressure of the warm and tenuous medium surrounding the cold and dense molecular clouds impacted by the jets. By comparing this pressure map with a pressure map from CO(1-0) to (4-3) ALMA data, we will quantify the changes in the external vs. internal pressure and, thus, in the stability of individual dense clouds after the jet passage. We will observationally determine, for the first time, the mass fraction of dense clouds that joins the outflow. We will examine whether the dissipation of the dense clouds that leads to their entrainment is primarily due to shocks, cosmic rays, or X-rays. From the density and the velocity of the warm H2, we will obtain a lower limit for the outflow duration based on how long ram pressure took to accelerate dense clouds to the observed velocities. From the mass and the velocity of the warm H2, we will compute the total molecular gas mass that resulted in the halo and got removed from the reservoir available for star formation. Combining gas and dust diagnostics, we will look for star formation variations along the jet. For this project, which will test fundamental physics models of the dense gas acceleration in million or billion solar mass outflows, we ask for ~2 hours of science time on the JWST. The observations will have a highly demonstrative value for the telescope, as IC5063 is a well studied galaxy, prototype of jet-driven winds.
High-eccentricity exoplanets are a unique class of planets that experience dramatic increases in insolation and tidal forcing near periastron passage. By observing the thermal response of the atmosphere before, during, and after periastron passage (the ‘flash-heating’ event), we can constrain physical processes within a single set of observations. We propose to utilize MIRI/LRS to observe a partial spectroscopic phase curve of the eccentric hot Jupiter HD 80606b. In conducting our spectroscopic observations from 12 hrs before through to 8 hrs after periastron, we will capture the time- and wavelength-dependent flux before, during and after HD 80606b’s flash-heating event. This information will allow us to constrain the internal heating of HD 80606b, probe variations in clouds and chemistry throughout HD 80606b’s orbit, and assess the role of dynamical mixing in HD 80606b’s atmosphere. Our proposed MIRI/LRS observations of HD–80606b will build upon the rich legacy of Spitzer, Hubble, and now TESS and bring a new experimental look into fundamental processes that shape the phase-curve observations of not only eccentric hot Jupiters, but all hot Jupiters.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 02016
Program Title: Revealing Low Luminosity Active Galactic Nuclei (RevealLAGN)
Principal Investigator: Anil Seth
PI Institution: University of Utah

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JWST will be the most sensitive tool ever built for studying the accretion onto supermassive black holes (SMBHs) at the centers of galaxies. While quasars and bright active galactic nuclei (AGN) provide spectacular examples of this accretion, a vast majority of galaxies have black holes accreting at much lower rates. Although these low luminosity AGN (LLAGN) are not as well studied or understood as their brighter counterparts, it is clear their inner structures differ significantly from the accretion disks in luminous AGN. JWST spectroscopy provides a unique opportunity to significantly advance our understanding of LLAGN. Our proposal focuses on getting IFU spectra from 1.7 to 28 microns for seven of the nearest LLAGN spanning four orders of magnitude in both black hole mass and accretion rate (these will also be complemented by two GTO targets). JWST’s spatial resolution will enable easy separation of the AGN from the host galaxy light providing us with spectral templates of low luminosity AGN spectra in the infrared for the first time. Detailed physical modeling of both the line emission and spectral energy distributions of these LLAGN spectra will reveal the physical structure of low luminosity AGN, and how it varies with the mass and accretion rate of the SMBH. We will also use these spectral templates to empirically determine the most sensitive lines and SED features for spectroscopically and photometrically identifying LLAGN in more distant galaxies where the AGN won’t be spatially resolved. RevealLAGN will both significantly enhance our understanding of AGN and open a new window for future AGN studies with JWST.
Eclipse mapping is an observational technique that measures an exoplanet's thermal structure as a function of both latitude and longitude yielding two dimensional maps of the planetary dayside. Multiwavelength eclipse maps propel these observations into the next dimension and provide an unprecedented view of a planet's three-dimensional dynamics, thermal structure, chemistry, and energetics. Here we propose to produce spectroscopic eclipse maps of the canonical hot Jupiter, HD 189733b, from 6 to 12 microns with MIRI LRS. These observations will measure the geographic distribution of dayside emission over these wavelengths, thereby constraining the global circulation patterns and relevant atmospheric timescales in HD 189733b with latitude, longitude and altitude. When combined with previous Spitzer/IRAC mid-IR photometric phase curves and eclipse maps, our proposed MIRI spectroscopic eclipse maps will paint the most detailed and complete picture to date of weather in a hot Jupiter atmosphere, refining general circulation models that aim to predict their climate.
Planets form and obtain their volatile inventories in disks around young stars. ALMA has recently completed a large program on the chemistry of 5 such disks at spatial resolutions of 10-15 au. The gas structure and chemical composition of their outer disk regions (>10 au) have been characterized in exquisite detail, revealing an impressive chemical and morphological diversity. We propose to use MIRI to obtain the complementary chemical composition of the inner 10 au of 4/5 of these disks (the 5th is part of a GTO program). The resulting data set will provide a complete chemical inventory from the small terrestrial planet-forming scales to the outer disk regions where e.g. comets may assemble. We will use the combined JWST-ALMA data set to retrieve the radial column density profiles of the main carriers of volatile C and O, of probes of the C/N/O/S gas-phase elemental ratios, and of key organic molecules across all planet-forming radii. This legacy data set will enable the best constraints to date on the composition of planet forming material at different disk radii, and on the dynamical and chemical links between different disk regions.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 02028
Program Title: Mapping A Distant Protocluster Anchored by A Luminous Quasar in the Epoch of Reionization
Principal Investigator: Fei Fei Wang
PI Institution: University of Arizona

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Theoretical models predict that luminous quasars should act as signposts for protoclusters in the young Universe. However, despite extensive searching, protoclusters traced by quasars have not yet been discovered in the epoch of reionization (EoR). Recent ALMA/JCMT sub-mm observations and Subaru narrow/broad band imaging of a luminous quasar at z=6.63 have finally revealed a spectacular overdensity of [CII] emitters, sub-mm galaxies, and Lyman alpha emitters, suggesting that it is the most distant known protocluster harboring quasar activity, and the first such system discovered in the EoR. An approved HST program will mosaic two 3.6'x3.6' fields, centered at the quasar and a galaxy merging system within this protocluster, respectively. The quasar, with both strong gas outflow as indicated by broad absorption lines and inflow as indicated by multiple metal absorption lines, is hosted by an extended massive merging galaxy. Moreover, the quasar host features an extremely broad [CII] line with a FWHM of 930 km/s, suggesting that this quasar resides in a deep gravitational potential and could be a progenitor of the brightest cluster galaxy (BCG).

We propose NIRSpec MSA observations to identify galaxies physically associated to this protocluster by targeting galaxies selected from HST observations. The MSA observations will allow us to map the 3D structure of the protocluster, measure AGN fraction of protocluster member galaxies, and characterize the physical properties of galaxies in the most dense structure yet known in the EoR. In addition, we will perform NIRSpec IFU observation of the quasar to study the formation of the BCG progenitor.
We propose an archival research project to study gas coma volatiles in a main-belt comet with the James Webb Space Telescope's NIRSpec and NIRCam instruments. Main-belt comets have dynamical properties consistent with an origin in the asteroid belt, but exhibit the behavior of comets. Despite repeated mass-loss episodes during perihelion passages consistent with water-ice driven sublimation, volatiles have never been observed at any main-belt comet. Measuring their volatile production rates and coma dust-to-gas mass ratios provides a better understanding of the subsurface preservation of water ice in the asteroid belt. With observations of 238P/Read from GTO program 1252, we expect to exceed previous upper limits by two orders of magnitude, yielding the first detection of water in an MBC coma, or a physically meaningful upper limit.
TYC 8988-760-1 is the most recently discovered imaged multi-planetary system, containing two young Jovian exoplanets seen at ~160 and 320 au (1.7" and 3" projected separations). We propose a comprehensive spectroscopic characterization of these two worlds using the NIRSpec IFU and MIRI LRS to obtain complete spectra of both planets spanning 1-12 microns at low resolution, for high fidelity measurements of fundamental planetary properties through atmospheric retrievals, and at high-resolution across 3-5 microns to measure elemental abundances, non-equilibrium chemistry, and cloud properties using forward modeling. Together these spectral datasets, spanning a wealth of molecular and atomic lines, will yield measurements of planetary temperatures, radii, atmospheric C/O ratio, metallicity, vertical mixing, clouds, and more. The combination of low- and high-resolution data will break degeneracies of these parameters with properties such as non-equilibrium chemistry and surface gravity. These observations will enable detailed comparative planetology assessing the atmospheres and formation pathways of these worlds against one another, other directly imaged planets, and young field brown dwarfs. The presence of two imaged planets in this system, and their brightness and wide separation from the host star, makes this system an extraordinarily favorable target for JWST exoplanet spectroscopy, and will efficiently yield exquisitely precise spectra for comparative study of their atmospheres to an unprecedented level.
The Galactic center (GC) offers a unique opportunity to conduct detailed and resolved studies of star formation in an extreme starburst-like environment. We propose to use JWST NIRCam to perform the deepest ever study of the Arches and Quintuplet clusters, two young (<5 Myr) and massive (10^4 Msun) clusters near the GC. These observations will allow us to identify cluster members to sub-solar masses (M > 0.4 Msun) for the first time, distinguishing between competing models for how the Initial Mass Function (IMF) behaves in such environments. This provides a critical benchmark for star formation theory, as the IMF is shaped by the physical processes driving star formation, and informs our understanding of unresolved stellar populations at high redshifts where starbursts were common. In addition, simultaneous long-wavelength observations will provide a census of infrared excess sources ~3 mags deeper than previous studies, from which we will test predictions regarding how strongly environmental conditions (such as external photoionization and dynamical interactions) influence circumstellar disk lifetimes. The combination of high spatial resolution, sensitivity, and field of view makes JWST uniquely suited to achieve these goals, which will impact many additional areas of astrophysics such as galaxy mass evolution, cosmic star formation, compact object production and merger rates in galactic nuclei, and planet formation in different environments.
Proposal Category: GO
Scientific Category: Large Scale Structure of the Universe
ID: 02046
Program Title: A definitive test of the dark matter paradigm on small scales
Principal Investigator: Anna Nierenberg
PI Institution: University of California - Merced
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The cold dark matter paradigm predicts that self-gravitating structures known as halos should form down to Earth masses. Below virial masses of ~10^8 Msun most of these halos must be devoid of stars and gas to match observations of Milky Way satellites. Thus, detecting the predicted population of dark halos below 10^8 Msun would be a triumph of the cold dark matter paradigm. Conversely, their absence would imply that dark matter cannot be cold, but must be of a more exotic nature. Strong gravitational lensing provides a direct probe of dark matter as lensed image fluxes and positions are sensitive to very low mass perturbations due to dark matter halos both within a lens galaxy and along the line of sight. We propose to measure the strongly lensed flux from the cold dust torus surrounding the accreting supermassive black hole powering quasars. The cold dust torus is an ideal source, as its size (~ 1-10 pc) is large enough to avoid microlensing, yet small enough to be sensitive to 10^7 Msun halos. This measurement will enable us to detect or rule out a warm dark matter mass function with a turnover as low as 10^6.5 Msun, equivalent that of a 10 keV thermal relic, for example. If we detect the turnover, we will prove dark matter is not cold. If we do not detect the turnover at these masses, nearly two orders of magnitude below the limit at which halos are expected to be mostly dark, it will prove the existence of a significant population of completely dark halos, verifying a key prediction of the cold dark matter paradigm. JWST MIRI provides the only possible means of attaining the flux and spatial precision at the wavelengths necessary to make this measurement.
We will observe four K giants with the Medium-Resolution Spectrometer (MRS) on JWST in order to solve an enduring problem in stellar astrophysics. Stellar models consistently underpredict the strength of molecular absorption bands observed in the mid-infrared, including the CO fundamental at 5 um, the SiO fundamental at 8 um, and the OH bands from 14 to 18 um. This discrepancy impacts infrared photometric calibration and astrophysical fields well beyond stellar atmospheres, from stellar population models in galaxies to the cosmic distance ladder. Our MRS observations will resolve the line structure in the mid-infrared absorption bands with better spectral resolution and sensitivity than ever before possible. The resulting spectra will reveal the temperature and other physical properties of the absorbing molecular layer as a function of wavelength. With these measurements, we can build a better generation of more accurate models of late-type stellar atmospheres.
Observations in far-infrared and (sub-)mm wavelengths have found evidence for a non-negligible amount of gas around ~20 nearby main-sequence stars with debris disks. This gas, located in the outer regions of the systems, is likely to have originated via collisions or evaporation of planetesimals due to dynamical instabilities. Gas detected in the optical range with spectroscopy, located much closer to the star, and attributed to the presence of evaporating bodies, has also been found in these systems, pointing towards these objects, also known as exocometes, as a possible transportation mechanism for volatiles from the outer regions of planetary systems, beyond the snowline, to the inner regions where rocky planets are located.

However, observations thus far have not been able to identify warm gas in intermediate regions, or the presence of water, and therefore we don't yet understand how the transportation mechanisms might compare to those observed in the solar system.

We propose to use NIRSpec fixed slit mid-resolution observations in the 3 to 5 micron range to look for volatiles in a sample of 5 debris disk stars with known millimetric and optical gas, in particular targeting the 4.5-5 micron water features that is not observable from the ground. The detection of CO and water could not only help constrain the amount and temperature of gas, key in planet formation studies, but also shed light into the dynamics and architecture of planetary systems, and have implications in astrobiological studies, such as water delivery theories.
A primary goal of exoplanet characterization is to use a planet's current composition to understand how that planet formed. For example, the C/O ratio has long been recognized as carrying important information on the enrichment via ices in the outer parts of the protoplanetary disk. JWST opens the door to characterization of the C/O ratio. However, the C/O ratio alone cannot unambiguously constrain the formation mechanism or location of an exoplanet. A new path forward is to measure both volatile (C, O) and refractory (Fe, Mg, Si) elemental abundances in ultra-hot Jupiters, which can remain hot enough to largely avoid the condensation of these elements. By measuring the refractory-to-volatile ratio, we can infer the rock-to-ice ratio of the atmosphere, which can distinguish various formation and migration scenarios. We propose to measure the 2.9-5.2 micron transmission spectrum of ultra-hot Jupiter WASP-178b with JWST/NIRSpec/G395H to complement UV-NIR observations from HST. This exciting planet shows large short-wavelength transit depths from Fe and SiO, allowing us to measure refractory elemental abundances. Combined with our proposed JWST spectra, we will measure the planets O, C, and refractory content and be able to constrain whether the planet formed inside or outside the H2O iceline, whether the planet formed via planetesimal- or gas-dominated accretion, and whether the planet formed in a carbon-depleted disk. Such measurements would represent the beginning of a paradigm shift in our ability to connect the present-day composition of exoplanets to the processes and building blocks that formed them.
Proposal Category: GO  
Scientific Category: Supermassive Black Holes and AGN  
ID: 02057  
Program Title: A JWST Study of the Link Between Supermassive Black Holes and Galaxies at Cosmic Noon  
Principal Investigator: Yue Shen  
PI Institution: University of Illinois at Urbana - Champaign  
Co-investigators: Jennifer Li University of Illinois at Urbana - Champaign, Patrick Hall York University, Qian Yang University of Illinois at Urbana-Champaign, Xin Liu University of Illinois at Urbana - Champaign, Hector Ibarra Medel University of Illinois at Urbana - Champaign, Luis Ho Peking University, Linhua Jiang Peking University, Jonathan Trump University of Connecticut, Donald Schneider The Pennsylvania State University, Yasaman Homayouni University of Connecticut, William Brandt The Pennsylvania State University, Keith Horne University of St. Andrews, Scott Anderson University of Washington, Bradley Peterson The Ohio State University

The measurement of the scaling relations between supermassive black hole (SMBH) mass and the properties of the host galaxy at cosmic noon (z~2) is crucial to understanding the co-evolution (or not) of SMBHs and galaxies, the nature of AGN feedback and self-regulated BH growth, and the forecast for the stochastic gravitational wave background from mergers of SMBHs. Given the difficulties of acquiring both reliable BH masses and host galaxy measurements in this regime, there is currently no consensus on whether or not such correlations exist at z~2. We propose pioneering JWST NIRCam ∼1-5 micron imaging and NIRSpec IFU ∼1-2 micron spectroscopy to constrain the correlations between SMBH mass and host stellar velocity dispersion, stellar mass and luminosity, using a unique sample of ten z~2 quasars with BH masses measured directly from reverberation mapping. This pilot JWST program is poised to deliver the most definitive constraints on the high-z SMBH-galaxy scaling relations to date, paving the way for future more ambitious programs. It will also enable a broad range of science, from stellar populations of massive quasar host galaxies, to kpc-scale quasar-driven outflows (e.g., in [OIII]5007), and provide a benchmark sample for comparative studies of massive galaxies at z~2 (e.g., star-forming and quiescent galaxies, obscured AGN hosts, etc).
We propose to observe the Galilean moon Callisto with NIRSpec IFU (G395H, 2.9 - 5.3 microns) to improve our understanding of the carbon and nitrogen chemical systems operating on this moon and gain insight into the formation conditions in the Jovian subnebula. We will investigate the nature of CO2 by characterizing its spectral signature and distribution across Callisto and by determining whether primordial deposits of ‘pure’ CO2 ice are present in the Valhalla and Asgard impact basins. We will investigate whether a 4.57-micron band detected on Callisto results from nitrogen-rich organics, which might have been delivered in dust grains from Jupiter’s irregular satellites. By characterizing 13CO2, a heavy stable isotope of CO2, we will probe Callisto’s formation environment. Because Earth’s atmosphere is opaque between 4.2 and 4.5 microns, investigation of solid-state CO2 on planetary bodies like Callisto is impossible using ground-based facilities. Similarly, the 4.57-micron band is heavily contaminated by Earth’s atmosphere, making assessment of this band highly challenging using ground-based facilities. JWST is therefore the only existing facility that can collect the high quality spectra required to complete this project’s objectives. We require 0.07 hours of science time, and 3.39 hours of total charged time, to make our three required observations. Collected NIRSpec spectra will be highly valuable for developing the spectroscopic priorities of the NASA Europa Clipper and ESA JUICE spacecraft missions to the Jovian system, which will both make close passes of Callisto.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02061
Program Title: Nucleosynthesis, Astrophysics, and Cosmology with IR Observations of a Gravitational Wave Counterpart

Principal Investigator: Ryan Foley

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The 2017 discovery of a binary neutron star (BNS) merger in gravitational waves (GWs) and light was a watershed moment. Using unique multi-messenger data, the community made major advances in a broad range of topics from $s$-process nucleosynthesis to compact-object formation to cosmology. While no other electromagnetic counterpart has yet been discovered, the second example will likely lead to new fundamental discoveries.

Cycle 1 and the next LIGO/Virgo/KAGRA observing run (O4) have high overlap. But simulations suggest that there will be only one O4 event visible to JWST - and it will likely be distant/faint. Nevertheless, the observations proposed here can answer several questions:

What fraction of the heaviest elements come from NS mergers?

What are the progenitors of BNS systems?

How fast is the Universe expanding?

NS mergers produce radioactive, $r$-process ejecta - a kilonova (KN) - whose spectral-energy distribution depends on its composition. Theory predicts that all KNe have a "red" component peaking in the IR, and tracking its evolution constrains the amount of heavy $r$-process material produced. The same observations can pinpoint the KN in its galaxy, possibly revealing the origin of the progenitor system, and constrain the system's inclination angle, breaking a degeneracy with distance in the GW data and improving the "standard siren" H0 measurement.
We propose a Small GO program (22.81 hrs Charged Time) to analyze the atmosphere of WASP-166b, a hot, puffy, super-Neptune exoplanet (P = 5.44354 d, M_p = 32.1 ± 1.6 M_earth, R_p = 7.1 ± 0.3 R_earth, T_{eq} = 1270 ± 30 K). We will conduct transmission spectroscopy of one transit of WASP-166b with NIRISS SOSS Order-1 (0.9 to 2.8 microns) and a second transit with NIRSpec BOTS G395M/F290LP (2.87 to 5.18 microns). These observations will allow us to constrain or place upper limits on the abundances of H2O, CO, CH4, CO2, C2H2, HCN, and NH3. WASP-166b is in a sparsely populated region of mass-insolation flux space known as the “hot Neptune desert”, therefore the planet’s formation history will help us probe the origin and nature of the desert. Our proposed transmission spectroscopy of WASP-166b will yield meaningful constraints on molecular abundances, metallicity, and C/O ratio, thereby providing insight into the composition, formation pathway, and evolution of planets of this class. Comparing our abundance results to theoretical models and observations of other planets will help assess theories for the origin and nature of the hot Neptune desert.
Proposal Category: GO
Scientific Category: Supermassive Black Holes and AGN
ID: 02064
Program Title: Dust in the Wind: testing a new paradigm for the nature of AGN feedback
Principal Investigator: David Rosario
PI Institution: Durham Univ.

ColInvestigators

Understanding the outflows driven by Active Galactic Nuclei (AGN) is of key importance for the modern view of galaxy evolution. A recent paradigm shift in our picture of dust in the vicinity of AGN offers promise for outflow science. We now know that a major part of an AGN's mid-infrared (MIR) dust emission comes from a polar structure that arises in a radiatively-accelerated dusty wind. Ground-based work has shown that similar polar emission is also found hundreds of pc away from the nucleus. If we can confirm that this extended polar emission is fundamentally connected to the pc-scale dusty wind, it will be our best evidence yet for a coherent dynamical connection between nuclear and galaxy-scale outflows.

This proposal will employ MIRI multi-filter imaging to unravel the nature of AGN-heated emission beyond the central 100 parsec. It relies on the unparalleled surface-brightness sensitivity of JWST, a strength that the best ground-based instruments cannot match. Our 8 targets are well-studied nearby Seyferts that already have established polar dust detections, and are carefully selected for their high-resolution ancillary data (HST imaging, AO-assisted and ALMA 3D spectroscopy).

The new JWST data will reveal the structure and colors of the extended dust. We will compare the geometry of the dust to the predictions of hydrodynamic simulations, determine its masses and energy content using state-of-the-art radiative transfer models, and explore its grain composition using novel diagnostics of broad-band spectral features. Along with ancillary kinematic information, we will test the salient hypothesis that the extended dust emission is shaped by a nuclear outflow.
Type Ia supernovae (SN Ia) have enormous importance to cosmology and astrophysics, but we still lack a detailed understanding of their progenitor systems and explosion mechanisms. At late times, in the nebular phase, the ejecta become optically thin, allowing us to "see through" the supernova and directly probe its composition, density, temperature, and kinematic structure. Nebular phase observations in the near-infrared and mid-infrared provide unique and powerful constraints on models, including the density-dependent nucleosynthesis of intermediate mass elements, radioactive iron-group elements, and stable iron-group elements. Here we propose to build a legacy, reference sample of JWST near- and mid-infrared nebular spectra of white dwarf supernovae with non-disruptive target-of-opportunity observations. In addition to normal SN Ia, we will also observe the diversity of thermonuclear supernovae, including extreme and peculiar objects. Our data will map progenitor and explosion scenarios to supernova outcomes, explaining different classes and narrowing the allowed model space for normal SN Ia. All data obtained will be made public immediately, with no exclusive access period.
The existence of luminous quasars at z > 7, just 800 Myr after the Big Bang challenges our understanding of supermassive black hole (SMBH) growth. In the standard picture, there is not enough time to grow their > 10^9 M_{\odot} SMBHs unless one invokes initial seeds >1000 M_{\odot} formed via exotic processes. During the epoch of reionization, the quasar radiation sources a cosmological-scale Hill region encoding its radiative history. Careful analysis of these proximity zones along the quasar sightline reveals a puzzling discrepancy. The quasar lifetimes are far too short to grow their SMBHs, implying at z > 7 either: 1) SMBHs grow faster than allowed by general relativity and the Eddington limit, obviating the need for massive seeds, or 2) the bulk of SMBH growth is enshrouded by dust. This degeneracy, inherent to 1D measurements along the quasar line-of-sight, can be broken using background (b/g) galaxies as Ly-alpha absorption probes to tomographically map the ‘light-echo’ produced by the foreground (f/g) quasar in 3D. We propose to combine NIRCam imaging with a powerful NIRSpec/MSA redshift survey to confirm 60 galaxies around two z > 7 quasars. This will set the stage for future deep integrations to definitively detect their light-echoes providing fundamentally new insights about SMBH growth possible only with JWST. The requested data will also: 1) enable the first measurement of quasar clustering at z > 7, providing a totally independent constraint on the quasar lifetime, 2) characterize the Ly-alpha fraction for a sample of 20 galaxies in the overdense quasar environment, 3) confirm 20 f/g galaxies to be correlated with absorption lines in the b/g quasar spectra.
Proposal Category: AR
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02074
Program Title: Galactic Archaeology with Brown Dwarfs in Medium-Deep JWST Observations
Principal Investigator: Russell Ryan
PI Institution: Space Telescope Science Institute
Co Investigators: Jenny Patience Arizona State University, Adam Schneider United States Naval Observatory Flagstaff Station, Michael Line Arizona State University, Christopher Willmer University of Arizona, Norbert Pirzkal Space Telescope Science Institute

We propose an Archival study of brown dwarfs and subdwarfs in the North Ecliptic Pole Time-Domain Field that is taken as part of the guaranteed-time observations of Windhorst et al. While this GTO program is designed as an extragalactic survey, we propose to use the uniquely sensitive observations to identify populations of brown dwarfs in the Galactic halo and thin disk. This field will be observed in eight NIRCam imaging bands and one NIRISS wide-field slitless band, and has HST data from WFC3 and ACS. These filters and this spectroscopic mode are ideal for not only identifying substellar objects, but also for discriminating between the effects of surface gravity and metallicity. Since this is a medium-deep field at modest Galactic latitude (b–33 deg), we expect to find 20-30 brown dwarfs out to <14 kpc (or <7 kpc above the Galactic plane). These JWST data permit the first direct exploration of brown dwarfs in the Galactic halo, as current studies rely on identifying candidate halo brown dwarfs by their extreme proper motions. Therefore this survey is a unique opportunity to characterize subdwarfs and the coolest known substellar objects (Y-dwarfs). Cycle 1 archival support is critical to develop the tools to identify substellar objects in large JWST datasets on a timescale such that follow-up studies can proposed.
Flows in the accretion disks surrounding supermassive black holes are central to virtually all observations of these objects, as well as to the consequences they have on their environments. This topic is complex because accretion disks are three-dimensional, turbulent, frequently self-gravitating, and strongly influenced by magnetic fields. Furthermore, in nearly all cases the system is too distant for detailed study. Sgr A* provides a unique laboratory to study this process through detailed imaging of the effects of the black hole on its environment, given that it is orders of magnitude closer than any other example. We will answer a key question about models of the accretion disk around Sgr A*, namely whether purely thermal or hybrid thermal/nonthermal models are appropriate. This ambiguity arises because plasma instabilities can accelerate electrons and push the electron distribution function into a non-thermal state. Hybrid models predict UV fluxes 3 orders of magnitude higher in that case than pure thermal models. We will make a definitive test of this prediction using a very deep search for the [Ne VI] line, ionization potential 126 eV, at 7.64 microns. This result fills in a key aspect of the theory of the nearest, and best studied, super-massive black hole and its accretion disk.
Proposal Category: GO
Scientific Category: Large Scale Structure of the Universe
ID: 02078
Program Title: A SPectroscopic survey of biased halos In the Reionization Era (ASPIRE): A JWST Quasar Legacy Survey
Principal Investigator: Feige Wang
PI Institution: University of Arizona
Collaborators: Joseph Hennawi University of California - Santa Barbara, XiaoHui Fan University of Arizona, JinYi Yang University of Arizona, Aaron Barth University of California - Irvine, Eduardo Banados Max-Planck-Institut fur Astronomie, Heidelberg, Rebekka Bieri Max-Planck-Institut fur Astrophysik, Laura Blecha University of Florida, Sarah Bosman Max Planck Institute for Astronomy, Zheng Cai Tsinghua University, Thomas Connor Jet Propulsion Laboratory, Tiago Costa Max-Planck-Institut fur Astrophysik, Frederick Davies Max Planck Institute for Astronomy, Roberto Decarli INAF, Osservatorio di Astrofisica e Scienza dello Spazio, Gisella De Rosa Space Telescope Science Institute, Alyssa Drake Max Planck Institute for Astronomy, Eiichi Egami University of Arizona, Anna-Christina Eilers Massachusetts Institute of Technology, Ryan Endsley University of Arizona, Emanuele Farina Max Planck Institute for Astrophysics, Melanie Habouzit Max-Planck-Institut fur Astronomie, Heidelberg, Yun-Hsin Huang University of Arizona, Linhua Jiang Peking University, Victoria Jones University of Arizona, Hyunsung Jun Korea Institute for Advanced Study, Koki Kakiichi University of California - Santa Barbara, Yana Khusanova Max Planck Institute for Astronomy, Alessandro Lupi Universita degli Studi di Milano-Bicocca, Chiara Mazzucchelli European Southern Observatory - Chile, Romain Meyer Max-Planck-Institut fur Astronomie, Heidelberg, Masafusa Onoue Max Planck Institute for Astronomy, Sofia Rojas Max Planck Institute for Astronomy, Jan-Torge Schindler Max Planck Institute for Astronomy, Michael Strauss Princeton University, Fengwu Sun University of Arizona, Benny Trakhtenbrot Tel Aviv University, Maxime Trebitsch Max Planck Institute for Astronomy, Bram Venemans Max-Planck-Institut fur Astronomie, Heidelberg, Marianne Vestergaard University of Copenhagen, Niels Bohr Institute, Marta Volonteri CNRS, Institut d'Astrophysique de Paris, Fabian Walter Max-Planck-Institut fur Astronomie, Heidelberg, Yunjing Wu Tsinghua University, Minghao Yue University of Arizona, Haowen Zhang University of Arizona

After two decades of search, the first large sample of quasars has been identified in the reionization era. We propose to obtain NIRCam observations of a flux-limited sample of 25 quasars at 6.5<z<=6.8 with extant high resolution ALMA sub-mm observations and deep optical-to-infrared spectra. This program will enable a powerful spectroscopic (WFSS mode) and imaging survey along the entire quasar light cones, resulting in the detection of Hbeta+[OIII] lines of ~350 galaxies at 5.3<z<7 over 240 arcmin² sky area, including 45 galaxies physically associated to the central quasars. It will finally resolve the long-standing question of whether the earliest supermassive black holes (SMBHs) reside in the most massive dark matter halos and inhabit large scale galaxy overdensities. We will simultaneously image the host galaxies and close companions of quasars, measure the masses of the central SMBHs and characterize quasar feedback with Hbeta+[OIII] emissions, providing unprecedented constraints on the connection between SMBHs and their hosts as well as their primordial environment. This program will also provide unparalleled constraints on cosmic reionization and galaxy formation by measuring ionizing photon escape ratios of faint galaxies and probing the circumgalactic media of galaxies at z~5-7. In addition, this survey will give the most accurate bright-end galaxy luminosity function and Hβ+[OIII] equivalent width measurements at z~5-7, complementary to the GTO JADES deep spectroscopic survey. Finally, the coordinated NIRISS parallel imaging will allow us to identify additional galaxies at z~6.5-6.8 to probe quasar-galaxy clustering at larger scales.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02079
Program Title: The Webb Deep Extragalactic Exploratory Public (WDEEP) Survey: Feedback in Low-Mass Galaxies from Cosmic Dawn to Dusk
Principal Investigator: Steven Finkelstein
PI Institution: University of Texas at Austin
Collaborators
Casey Papovich Texas A & M University, Norbert Pirzkal Space Telescope Science Institute, Jennifer Lotz Gemini Observatory, Northern Operations, Micaela Bagley University of Texas at Austin, Danielle Berg University of Texas at Austin, Marco Castellano INAF, Osservatorio Astronomico di Roma, Oscar Chavez Ortiz University of Texas at Austin, Katherine Chworowsky University of Texas at Austin, Romeel Dave University of Edinburgh, Institute for Astronomy, Mark Dickinson NSF’s NOIRLab, Vicente Estrada-Carpenter Texas A & M University, Harry Ferguson Space Telescope Science Institute, Adriano Fontana INAF, Osservatorio Astronomico di Roma, Mauro Giavalisco University of Massachusetts - Amherst, Andrea Grazian Osservatorio Astronomico di Padova, Norman Grogin Space Telescope Science Institute, Anne Jaskot Williams College, Intae Jung NASA Goddard Space Flight Center, Jeyhan Kartaltepe Rochester Institute of Technology, Lisa Kewley Australian National University, Allison Kirkpatrick University of Kansas Center for Research, Inc., Dale Kocevski Colby College, Rebecca Larson University of Texas at Austin, G Leung University of California - San Diego, Jasleen Matharu Texas A & M University, Adam McCarron University of Texas at Austin, Priya Natarajan Yale University, Barry Rothberg George Mason University, Laura Pentericci INAF, Osservatorio Astronomico di Roma, Swara Ravindranath Space Telescope Science Institute - CSA, Vicente Rodriguez-Gomez Universidad Nacional Autonoma de Mexico (UNAM), Russell Ryan Space Telescope Science Institute, Raymond Simons Space Telescope Science Institute, Rachel Somerville Rutgers University, Greg Snyder Space Telescope Science Institute, Jonathan Trump University of Connecticut, Stephen Wilkins University of Sussex, L. Y. Aaron Yung NASA Goddard Space Flight Center, Daniel McIntosh University of Missouri - Kansas City, Kameswara Mantha University of Missouri - Kansas City, Sandra Faber University of California - Santa Cruz

We propose WDEEP: The Webb Deep Extragalactic Exploratory Public Survey. WDEEP leverages efficient parallel observations over 121.7 hr with NIRISS in the Hubble Ultra Deep Field (HUDF) and NIRCam in the HUDF-Par2 field to constrain the physical processes dominating feedback in galaxies from z~1-12. Observing with JWST in the HUDFs leverages off the deepest optical imaging from Hubble and makes WDEEP a premier legacy field for both missions.

WDEEP observes deeply with NIRISS (60-190 ks) to detect faint emission lines (~ 10^-18 cgs) for >1000 mostly low-mass (log M/Msol = 7-9) galaxies. WDEEP-NIRISS will enable robust constraints on the low-mass end of the mass-metallicity relation and constrain stochastic star-formation by probing H-alpha based star-formation rates to 0.1 Msol/yr in these low-mass galaxies. These measurements will limit chemical enrichment and feedback physical prescriptions in models, which are currently unconstrained at these masses.

In parallel, WDEEP will obtain the deepest 6-band NIRCam imaging (m~30.6-30.9) on the HUDF-Par2 field. WDEEP-NIRCam will probe z > 12, and constrain stellar feedback prescriptions in models by precisely measuring the shape of the faint-end of the UV luminosity function at z~10. These data will provide unprecedented morphological detail in galaxies at all redshifts, and reconnoiter the sites of first black hole formation.

Being public immediately, WDEEP follows in the footsteps of the Hubble deep field programs, enabling the community to explore the power of Webb when pushed to its limits. As a treasury program, we are committed to the rapid reduction and release of high-quality reduced data products and catalogs.
Shocks from nuclear jets in galaxies have profound effects on their interstellar medium, injecting energy from the central Active Galactic Nucleus (AGN) which excites and ionizes gas, dissociates molecules, and ablates dust grains. Tracers of the shocked gas used to quantify this energy injection can track the response of the interstellar medium to specific forms of feedback. We propose NIRCam observations of nearby Seyfert galaxy NGC 4258 to map these tracers of ionized gas, neutral gas, molecular gas, and dust in the nucleus and inner galactic disk to quantify the impact of the observed ‘anomalous’ jet on the interstellar medium. JWST and NIRCam provide a first-ever opportunity to observe the impacts of a nuclear jet through the disk of a galaxy at parsec-scale resolution using infrared diagnostics with little extinction by dust. The comprehensive set of tracers obtained in this program probing the physics of the jet / interstellar medium interaction will provide a detailed picture of feedback in a nearby AGN-hosting galaxy and will inform observations of more distant, high-redshift galaxies whose disks even JWST will be unable to resolve. Early cycle JWST imaging of NGC 4258 also provides excellent archival value to the astronomical community, providing a ‘finder-chart’ for specific dynamic regions to be followed-up with future JWST spectroscopic observations.
The nearby hot super-Earth planet 55 Cancri e shows variable occultation depths, i.e. variable amounts of dayside emission. The origin of these variations could lie in several phenomena, intrinsically dependent on the planetary atmospheric properties or surface features. We aim to identify the origin of this variation, and specifically test whether it originates from different sides of the planet being visible due to a 3:2 spin-orbit resonance. Even for an atmosphereless ``bare rock'', this asynchronous rotation would produce a magma pool and mineral vapors over the day side that depend on the local surface conditions, giving rise to variability. If the surface is dominated by silicates, as is likely for a hot rocky planet, the extreme temperatures of the day side would produce detectable amounts of SiO gas from the vaporization of SiO2 in the morning that subsequently rains out and recrystallizes back to SiO2 in the evening. If the planet is in a 3:2 spin-orbit resonance, every second occultation would show the same face of the planet with the emission highly correlated. The planet could also be covered by a massive atmosphere that provides the thermal inertia, even in the case that the variability is unrelated to asynchronous rotation, to explain the observed redistribution of heat. Spectral features, potentially variable, may then be detected. We thus aim to answer the following questions: 1) Is there a massive atmosphere or is it essentially a bare rock with vaporized SiO? 2) If a bare rock, can the variability be explained by asynchronous rotation? This will help us understand the origin and nature of hot super-Earths, of which 55 Cnc e is the best representative.
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02091
Program Title: Detecting the Synthesis of the Heaviest Elements with Photometry of a Kilonova in the Optically Thin Phase
Principal Investigator: Maria Drout
PI Institution: University of Toronto
Coinvestigators
Charles Kilpatrick Northwestern University, Alexander Ji Carnegie Institution of Washington, Aaron Tohuvavohu University of Toronto, Daryl Haggard McGill University, Ryan Foley University of California - Santa Cruz, Armin Rest Space Telescope Science Institute, Ryan Ridden-Harper Space Telescope Science Institute, Tea Temim Space Telescope Science Institute, Joshua Simon Carnegie Institution of Washington, James Annis Fermi National Accelerator Laboratory (FNAL), Patrick Aleo University of Illinois at Urbana - Champaign, Iair Arcavi Tel Aviv University, Annalisa Calamida Space Telescope Science Institute, Deep Chatterjee University of Illinois at Urbana - Champaign, Jeff Cooke Swinburne University of Technology, David Coulter University of California - Santa Cruz, Georgios Dimitriades University of California - Santa Cruz, Ori Fox Space Telescope Science Institute, Alexander Gagliano University of Illinois at Urbana - Champaign, Suvi Gezari University of Maryland, Daichi Hiramatsu Las Cumbres Observatory Global Telescope Network, Dale Howell Las Cumbres Observatory Global Telescope Network, Saurabh Jha Rutgers the State University of New Jersey, David Jones University of California - Santa Cruz, Daniel Kasen University of California - Berkeley, Robert Kirshner Harvard University, Nora Luetzgendorf Space Telescope Science Institute, Philip Macias University of California - Santa Cruz, Curtis McCully Las Cumbres Observatory Global Telescope Network, Gautham Narayan University of Illinois at Urbana - Champaign, Antonella Palmesse Fermi National Accelerator Laboratory (FNAL), Yen-Chen Pan National Central University, Anthony Piro Carnegie Institution of Washington, Enrico Ramirez-Ruiz University of California - Santa Cruz, Cesar Rojas-Bravo University of California - Santa Cruz, Russell Ryan Space Telescope Science Institute, David Sand University of Arizona, Matthew Siebert University of California - Santa Cruz, Marcelle Soares-Santos University of Michigan, Louis-Gregory Strolger Space Telescope Science Institute, Kirsty Taggart University of California - Santa Cruz, Sanaporn Tinyanont University of California - Santa Cruz, Stefano Valenti University of California - Davis, Qian Wang The Johns Hopkins University

Approximately half of all elements heavier than iron form through rapid-neutron capture. Yet the cosmic origin of these “r-process” elements has been debated for over 60 years. In 2017, the discovery of a kilonova associated with the gravitational wave source GW170817 partially unraveled this mystery—firmly establishing that neutron star mergers do synthesize r-process elements. However, in this discovery’s wake many questions remain. In particular, it is unclear whether GW170817 synthesized any of the heaviest “third peak” or actinide elements. As a result, we are still uncertain whether NS mergers are the only - or even the dominant - site of r-process production. We propose to use JWST/NIRCam and JWST/MIRI to tackle this open question by observing a new kilonova discovered during LIGO/Virgo/KAGRA Observing Run 4. We will carry out our observations between ~30-120 days post-merger when the ejecta is optically thin. During this nebular phase, the bolometric luminosity will trace the instantaneous heating rate due to radioactive decay; with decline rates that vary depending how far up the periodic table the r-process proceeded. Constraining the bolometric luminosity at these epochs requires broad-band coverage between ~1-10 microns to depths of ~25-28 mag (AB). Hence, JWST is the only facility capable of carrying out these observations.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02092
Program Title: Unveiling stellar birth in a cosmologically common cradle
Principal Investigator: Steven Longmore
PI Institution: Liverpool John Moores University

Colleagues: Jens Kauffmann Massachusetts Institute of Technology, Thushara Pillai Boston University, Stella Offner Department of Astronomy, University of Texas, Shuo Kong University of Arizona, Robert Guterluth University of Massachusetts - Amherst, Tracy Huard University of Maryland, Dunham, Michael State University of New York at Fredonia, Neal Evans University of Texas at Austin, Hector Arce Yale University, Klaus Pontoppidan Space Telescope Science Institute, James Urquhart University of Kent, Sudeshna Patra Indian Institute of Science Education and Research Tirupati, Jessy Jose Indian Institute of Science Education and Research Tirupati, Marc Pound University of Maryland, Christoph Federrath Australian National University

We will use the unparalleled sensitivity, resolution and wavelength coverage of JWST to perform a complete census of the embedded protostellar population down to 0.1 Lsun in the most massive, dense and quiescent molecular gas cloud in the Galaxy with unambiguous signs of very early star formation. Lying in the Central Molecular Zone of the Galaxy with 1 to 2 orders of magnitude higher gas density, temperature and pressure than regions in the disk, the cloud’s properties are similar to the global gas conditions in galaxies at the peak of the cosmic star formation rate density (z = 1 - 3), so represent more cosmologically “typical” conditions for star and planet formation/evolution than Solar neighbourhood clouds. Combined with ALMA data, the JWST observations will enable us to determine how these initial conditions affect the formation and subsequent evolution of protostellar systems, and thereby answer fundamental open questions related to the universality of star formation laws/relations and the dependence on environment of protostellar formation and evolution.
The most prominent manifestation of early star formation is energetic feedback in the form of a protostellar jet and/or wind, emanating from the disk and the central few au near the new star. Outflows remove the angular momentum from infalling disk material and assist the accretion process through the disk. Although there have been many theoretical and numerical studies on outflow launching, it has proven very challenging to observationally measure the physical conditions at the base of the outflow. In particular, the proposed mechanisms predict high gas temperatures (> 1000 K) in the vicinity of the launching region. Meanwhile, the Atacama Large Millimeter/submillimeter Array has successfully observed the launching of the cooler molecular outflows down to au scales in protoplanetary disks. One such a well-studied object is the Class I protostar TMC1A. This proposal aims to spatially map the hot atomic and molecular gas towards the TMC1A protostar and disk using JWST in order to understand the physical conditions of the launching region. In this program, we will target the ro-vibrational lines of CO, HCN, H2O, and H2, as well as a set of atomic H lines and one [Fe II] line, that will permit us to examine the accretion and high-temperature jet, respectively. Previous observations have detected (but not spatially resolved) some of the hot molecular lines towards TMC1A, ensuring the feasibility of this program. With the spatial information, sensitivity, and wavelength coverage of NIRSPEC IFU on JWST, these observations will significantly advance our understanding of the physical conditions in the outflow launching region of young protostellar systems.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02107
Program Title: A JWST-HST-VLT/MUSE-ALMA Treasury of Star Formation in Nearby Galaxies
Principal Investigator: Janice Lee
PI Institution: California Institute of Technology
Co-investigators
Karim Sandstrom University of California - San Diego, Adam Leroy The Ohio State University, Eva Schinnerer Max-Planck-Institut fur Astronomie, Heidelberg, David Thilker The Johns Hopkins University, Kirsten Larson California Institute of Technology, Daniel Dale University of Wyoming, Simon Deger California Institute of Technology, Mederic Boquien Universidad de Antofagasta, Erik Rosolowsky University of Alberta, Eric Emsellem European Southern Observatory - Germany, Ralf Klessen Zentrum fur Astronomie - Universitat Heidelberg, Alberto Bolatto University of Maryland, Brent Groves University of Western Australia, Kathryn Kreckel Astronomisches Rechen-Institut Heidelberg, Simon Glover Universität Heidelberg, Dyas Utomo Associated Universities, Inc., Thomas Williams Max-Planck-Institut fur Astronomie, Heidelberg, Francesco Santoro Max-Planck-Institut fur Astronomie, Heidelberg, Patricia Sanchez-Blazquez Universidad Autonoma de Madrid (UAM), Diederik Krijissen Zentrum fur Astronomie - Universität Heidelberg, Eric Koch Smithsonian Astrophysical Observatory, Jaeyeon Kim Heidelberg Institute for Theoretical Studies, Annie Hughes Universite de Toulouse, Kathryn Grasha Australian National University, Chris Faesi Max-Planck-Institut fur Astronomie, Heidelberg, Melanie Chevance Universitat Heidelberg, Jeremy Chastenet Ghent University, Ashley Barnes Universität Bonn, Argelander Institute for Astronomy, Francesco Belfiore INAF, Osservatorio Astrofisico di Arcetri, Firenze, Frank Bigiel Universität Bonn, Argelander Institute for Astronomy, Xian Cao Laboratoire d'Astrophysique de Marseille, Andreas Schruba Max-Planck-Institut fur extraterrestrische Physik, Jiayi Sun The Ohio State University, Eve Ostriker Princeton University, Rupali Chandar University of Toledo, Laura Lopez The Ohio State University, Antonio Usero Observatorio Astronomico Nacional, Jerome Pety Institut de Radioastronomie Millimetrique, Grenoble, Toshiki Saito Max-Planck-Institut fur Astronomie, Heidelberg, Sharon Meidt Sterrenkundig Observatorium, Universiteit Gent, Amy Sardone The Ohio State University

We propose a Treasury program to obtain 2-21 micron NIRCam+MIRI imaging of the unique sample of 19 nearby (d < 20 Mpc) star-forming main sequence galaxies with public HST, ALMA, and VLT-MUSE data. By resolving IR emission across these 19 morphologically diverse galaxies into individual regions and clusters (5-50 pc scales), the proposed JWST measurements will enable a complete inventory of star formation activity in our targets, accurately measure the mass and age of their stellar clusters, pinpoint the youngest embedded clusters, and reveal the physical state of the small dust grains that heat the ISM. We will generate and rapidly release high level data products that will fuel diverse, high impact science in the fields of star formation, feedback, ISM physics and galaxy evolution. In combination with UV-optical Hubble imaging of 10,000 clusters, MUSE spectroscopy mapping of 20,000 HII regions, and 12,000 ALMA-identified molecular clouds, our team will use the Treasury data to measure the timescales and efficiencies of the earliest phases of star formation and stellar feedback, build the first empirical model of how small dust grain properties depend on local ISM conditions, and quantitatively establish how dust-reprocessed starlight traces star formation activity and mass, all across a representative range of conditions in the z=0 universe. In short, this Treasury will provide a revolutionary data set to the JWST community early on, spur major scientific advances, and build on recent legacy programs of HST, ALMA and MUSE.
Proposal Category: AR
Scientific Category: Supermassive Black Holes and AGN
ID: 02108
Program Title: Constraining the Seeding and Growth of First Black Holes via Observable Signatures from the Early Universe
Principal Investigator: L. Y. Aaron Yung
PI Institution: NASA Goddard Space Flight Center
CoInvestigators: Jonathan Gardner NASA Goddard Space Flight Center, Rachel Somerville Rutgers University, Michaela Hirschmann DARK, Niels Bohr Institute, U. of Copenhagen, Greg Bryan Columbia University in the City of New York, Zoltan Haiman Columbia University in the City of New York, Stephane Charlot CNRS, Institut d’Astrophysique de Paris, Anna Feltre SISSA International School for Advanced Studies, Eli Visbal University of Toledo, Steven Finkelstein University of Texas at Austin, Jonathan Trump University of Connecticut

The physical processes governing the formation of the seeds of supermassive black holes, as well as how they grow in the early universe, are two fundamental unanswered questions in galaxy formation and cosmology. The unprecedented sensitivity of JWST’s instruments hold exciting potential for probing the growth of galaxies and black holes (BHs) in the very early Universe. However, detailed theoretical models are essential for interpreting these observations. With the goal of establishing a connection between the "ground-level", small-scale physical processes and the "top-level" observable signatures, we propose to construct an efficient, physics-based modeling pipeline that self-consistently simulates the co-evolution of BHs and galaxies, and produces predictions of their physical and observable properties over a wide redshift and halo mass range. This will be done by incorporating two essential new components into a well-established galaxy formation framework: 1) a suite of models representing different scenarios for BH seed formation and BH accretion, and 2) population synthesis and nebular line emission models that account for radiation from both stars and accreting BH. With this novel modeling pipeline, we will be able to 1) explore the implications of different BH seeding and accretion models for physical BH and host properties at high redshift, as well as observable quantities such as emission line luminosity functions, colors, and line ratios; 2) identify observables that can optimally constrain seeding and accretion models; and 3) create mock catalogs containing synthetic spectra and photometry, which can guide the design of future JWST observational programs.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02110
Program Title: Ultra-deep continuum spectroscopy of quiescent galaxies at 1.0<z<2.5: chemical abundances and stellar kinematics
Principal Investigator: Mariska Kriek
PI Institution: University of California - Berkeley
ColInvestigators:
Aliza Beveridge University of California - Berkeley, Charlie Conroy Harvard University, Andrew Newman Carnegie Institution of Washington, Marijn Franx Universiteit Leiden, Pieter van Dokkum Yale University, Rachel Bezanson University of Pittsburgh, Sedona Price Max-Planck-Institut fur extraterrestrial Physik, Katherine Suess University of California - Berkeley, Guillermo Barro University of the Pacific, Lamiya Mowla University of Toronto, Brian Lorenz University of California - Berkeley, Adam Muzzin York University, Mauro Stefanon Universiteit Leiden, Danilo Marchesini Tufts University, Ivo Labbe Swinburne University of Technology, Alice Shapley University of California - Los Angeles, N. Forster Schreiber Max-Planck-Institut fur extraterrestrial Physik

One of the most remarkable discoveries from the past two decades in extra-galactic astronomy is the finding of a large population of high-redshift galaxies with very low star formation rates. The existence of these quiescent galaxies has yet to be explained, largely due to the difficulty of obtaining high-quality spectra. Here we propose to remedy this situation by obtaining deep rest-frame optical spectra of a sample of quiescent galaxies at 1.0<z<2.5 with JWST/NIRSpec. Exploiting the large area of the UltraVISTA-COSMOS-DASH field we have identified an exceptional pointing for which we can observe 16 bright quiescent galaxies simultaneously. The resulting spectra will be of unparalleled quality, enabling accurate measurements of numerous Balmer and metal absorption lines. This program will yield the first statistical sample of 1.0<z<2.5 quiescent galaxies with robust stellar ages, metallicities, and chemical abundance patterns. Furthermore, the spatial resolution enables spatially resolved kinematics. These unprecedented measurements will (i) reveal when, how fast, and how efficient these galaxies formed their stars, (ii) constrain the importance of feedback in their star-forming phase, (iii) provide new insight into the physical mechanism responsible for quenching star formation, (iv) show if and how galaxies grow after becoming quiescent, and (v) constrain when and how early-type galaxies obtained their current dynamical structures. We will also observe faint quiescent and star-forming galaxies, enabling environmental studies and unique investigations relying on ultra-faint emission lines. Given the extraordinary nature of this dataset, we waive the proprietary time.
In the past decade, transiting exoplanets have been one of the most successful in terms of the atmospheric characterization of exoplanets. The technique of transmission spectroscopy - the wavelength-dependent change in the planetary radii due to opacity sources in its atmosphere - in particular, has been one of the main workhorses of the field in terms of providing constraints on the atmospheric elemental abundances in gas giant exoplanets. To date, this technique relies on one simple, key assumption: the terminator region we observe during transit is homogeneous. Here, we aim at putting this assumption to the test by exploring transit lightcurve asymmetries indicative of inhomogeneities at the morning or evening limbs in one of the most promising targets to search for this effect. Due to the exquisite spectrophotometric precision enabled by the James Webb Space Telescope, our observations will be able to constrain wavelength-dependent morning-to-evening depth differences down to 50 ppm, and extract the very first near-infrared transmission spectrum of the morning and evening of an exoplanet. This unprecedented set of spectra will provide strong constraints on the temperature and/or cloudiness levels at the limbs, providing a benchmark dataset with which to put modelling techniques such as Global Circulation Models to the test.
Type Ia Supernovae (SNe Ia) are the thermonuclear explosions of white dwarf stars, which originate from binary star systems and synthesize roughly half of the iron-group elements in the universe. The nature of the progenitors and the explosion mechanism is an open question. Understanding SNe Ia is foundational for the late stages of stellar evolution, the origins of the elements, and controlling systematic errors related to the use of SNe Ia as cosmological rulers. Observational estimates of the nuclear burning products in SNe Ia probe the progenitor and explosion. JWST provides an entirely new window of opportunity as there are spectral lines with unique information in the MIR. We request 21.1 hours of time to obtain 3 Medium resolution MIRI spectra 100–500d past maximum light for the nearest SNe Ia discovered in 2021-2022. The progenitor and explosion mechanism will be constrained using spectra acquired in three physical regimes: 1) 100-200d which measures radioactive Co and the intermediate mass elements, 2) 200-300d where hard gamma-rays, non-local effects, and the appearance of forbidden lines of neutron rich elements probe the progenitor density, 3) 400-500d where positrons deposit energy locally revealing the radioactive cobalt distribution. One of goals of JWST is to reveal the origin of heavy elements and how they feedback into the universe. The sensitivity and resolution of MIRI produce resolved line profiles, probing the element distribution. MIRI spectra will also show many isolated forbidden lines of isotopes with known wavelengths. The atomic physics learned will provide insight into many transients to come.
Core-collapse supernovae (CC SNe) are explosions of massive >10 Msun. CC SNe with hydrogen rich envelopes, type II SNe (SNe II), are the most common stellar explosions and are the main producers of heavy elements in the universe. As a result the study of these cosmic explosions probes the chemical evolution of the universe, sheds light on the composition of dust in our solar system, and ultimately the genesis of life. Moreover, molecules have been observed in the ejecta that form dust and determine which elements are present in interstellar gas and which are tied up in cosmic dust. Despite the prevalence of CC SNe, their physics is not well understood. The explosion of CC SNe takes seconds, whereas the SN light emitted and observed from the extended envelope evolves on timescales of weeks to years. However, the explosion mechanism can be determined by late-time observations of the SN when the core region is exposed. We request 22.1 h of non-disruptive ToO time to obtain 3 mid-infrared (MIR) and 3 near-infrared (NIR) spectra of a SN II between 50 and 200 days from explosion. This program will answer fundamental questions about the progenitor and explosion physics and the life-cycle of elements. The MIR has many isolated lines and JWST will obtain high resolution and signal-to-noise data which is necessary to determine: 1) the pre-explosion mass loss history, 2) the distribution of elements produced during the stellar evolution and explosion, 3) the possible role of CC SNe in the production of r-process elements, 4) the formation of new, warm dust via SiO, 5) and whether the early cold carbon-dust is primordial or freshly formed.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02123
Program Title: A Pathfinder for JWST Spectroscopy: Deep High Spectral Resolution Maps of Galaxies over 1<z<6
Principal Investigator: Susan Kassin
PI Institution: Space Telescope Science Institute

We propose deep, spatially resolved NIRSpec MSA near-IR spectroscopy of ~40 galaxies at redshifts 1<z<6 in the Hubble Ultra Deep Field. We will use the higher resolution R~2700 grating and "slitlet stepping" across the galaxies to obtain spatially resolved spectroscopy of emission and absorption lines in 2-D. Slitlet stepping exploits the multiplex and sensitivity advantages of the MSA to carry out a survey in a vastly shorter time than a large IFU sample would require.

The spectroscopic maps of restframe optical and near-UV lines will break new ground in measuring evolution of galaxy outflows, and the evolution of rotation vs. disordered motions, as massive galaxies evolve from an era dominated by filamentary cold-mode accretion to primarily hot-mode accretion and AGN feedback. These high-S/N spatial maps will enable: comparisons of the kinematics of gas and stars; Balmer-decrement measurements for both the broad (wind) and narrow (ISM) components of emission lines; spatially resolved nebular diagnostics of metallicity, excitation, and ISM pressure; AGN and shock signatures in both the centers and extended regions of galaxies; and star-formation and extinction maps from multiple spectroscopic indicators. These observations will be made public immediately, and will serve as a pathfinder for the JWST community to explore the revolutionary science return from deep JWST spectroscopy of high-z galaxies at high spatial and spectral resolution.
Using cold brown dwarfs to understand Jupiter-like atmospheres hinges on defining and explaining their diverse properties. In this JWST proposal we have used the parallax sample of the reddest/faintest brown dwarfs to define a sample of 12 sources that share a common mid infrared color -- our proxy for temperature -- but show meaningfully different 4.5 micron absolute magnitudes. Guided by what we have found for warmer brown dwarfs, we will use JWST data on this sample to map the diversity of cold brown dwarfs in (A) cloud properties (B) metallicity (C) gravity (D) binarity (E) overall chemistry or a combination of two or more of these properties. Understanding how each of those parameters alters the observable properties of a brown dwarf or giant exoplanet is crucial to interpreting cold worlds beyond our own. Using JWST spectra and photometry, we will compute bolometric luminosities for all 12 objects in our sample and use those values to anchor our mid infrared color binning. We will then compare and contrast spectral features at the peak of the spectral energy distribution that can be attributed to any of the known secondary impacts listed above. In doing so, this proposal will create a JWST legacy observational road map for both low-mass brown dwarfs and cold giant exoplanets to interpret the complex data emerging from extrasolar Jupiter-like objects.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Solar System Astronomy
ID: 02127
Program Title: Frozen Oort Cloud Comet Hale-Bopp
Principal Investigator: Michael Kelley
PI Institution: University of Maryland
Co Investigators
Silvia Protopapa Southwest Research Institute, Cyrielle Opitom Royal Observatory Edinburgh, Colin Snodgrass University of Edinburgh, Institute for Astronomy, Davide Farnocchia Jet Propulsion Laboratory, Marco Micheli ESA NEO Coordination Centre, Adam McKay American University

We propose to observe the Great Comet C/1995 O1 (Hale-Bopp) at 46 au from the Sun, distances where many surface ices are thermally stable. With a modest 11.2 hr program, a near-infrared spectrum can be obtained, providing physical information on the composition of cold cometary surfaces. This wavelength range contains diagnostic spectral features from water, CO2, and methanol ice. Such data would enable studies of cometary volatiles in a unique context: on the surface of an Oort cloud comet at distances equivalent to the Kuiper Belt. No other observatory can spectroscopically observe Hale-Bopp in the near-infrared, and no other comet will be observable at this distance in JWST’s lifetime. This, and future studies of cometary surfaces with JWST, will lay the groundwork that, together with spacecraft missions to comets, will enable us to assess cometary nuclei under a wide range of physical circumstances.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02128
Program Title: The First Resolved View of Individual Star Formation Across a Spiral Arm
Principal Investigator: Erik Rosolowsky
PI Institution: University of Alberta
CoInvestigators
Eric Koch Smithsonian Astrophysical Observatory, Adam Leroy The Ohio State University, Karin Sandstrom University of California - San Diego, Juliane Dalcanton University of Washington, Benjamin Williams University of Washington, Adam Smercina University of Washington, Lent Johnson Northwestern University, Thomas Williams Max-Planck-Institut fur Astronomie, Heidelberg, Dyas Utomo Associated Universities, Inc., Jeremy Chastenet Ghent University, Margaret Lazzarini University of Washington, I-Da Chiang University of California - San Diego

We propose parallel MIRI and NIRCam observations of M33, the nearest low-inclination spiral galaxy to the Milky Way (d=840 kpc). Our primary science goal is to produce the first-ever high resolution view of star formation across a propagating spiral arm. This view allows us to quantify the timescales of star formation and stellar cluster assembly. Our observational strategy uses two-band MIRI observations (F560W and F2100W) over a 5.5 sq. kpc region spanning the southwest spiral arm of the galaxy to detect YSOs in a region with rich ISM and HST data. Parallel NIRCam observations in four bands (F090W, F200W, F360M, F444W) will simultaneously map a 6.5 sq. kpc area in center of the galaxy, resolving the full stellar population to measure spatially-resolved star formation histories, PAH cooling, and embedded stellar cluster populations. We will be able to directly answer several long-standing questions about the star formation process including: Do extragalactic and galactic approaches to measuring star formation rates agree in spiral galaxies? How long are molecular clouds quiescent? How long are they dark? Does low mass star formation precede high mass star formation? (How much) Do molecular clouds continue grow after star formation begins?
We propose to begin the mid-infrared parsec-scale study of dust-enshrouded stellar populations in galaxies beyond the Magellanic Clouds. Building on methods established by Spitzer observations of the SMC and LMC, we will identify and characterize massive young stellar objects (MYSOs) and embedded star clusters, using NIRCam and MIRI imaging at 2, 4.4, 10, and 21 um. We will observe an area of ~2·3 sq. kpc covering spiral features in each of 3 galaxies (M33, NGC 300, NGC 7793) at distances of ~1, 2, 3 Mpc. In each galaxy, we expect to find >~150 clusters dominated by emission from individual MYSOs. Study of this early embedded phase, which lasts at most 2-3 Myr, hold critical clues to the conditions that ignite and extinguish star formation. Together with existing HST and ALMA CO imaging, we will build a foundational dataset to answer key questions on star formation at parsec scales, including the timescales for progression from molecular cloud to embedded cluster to revealed cluster; the rate and efficiency of star formation; and the form of the star formation law.

This program will serve as a pathfinder for study of the physical properties of MYSOs and embedded stellar clusters out to a few Mpc, and for interpretation of MIR imaging of clusters and clumps at larger distances. New SED modeling techniques are needed to interpret the photometry, which we are developing and will release as part of this program. The data broadly enable studies of all other objects tiny, dusty, and mid-infrared bright, including evolved stars. We thus will waive the proprietary period to facilitate community science and planning for spectroscopic and other follow-up studies.
The Extragalactic Background Light (EBL) as an integrated history of the early universe is important for the study of unresolved star formation. However, previous EBL measurements suffer from residual contamination from strong foregrounds, the zodiacal light (ZL). We propose to observe Galilean satellites eclipsed in the Jovian shadow as occulters to detect the absolute EBL intensity without any ZL uncertainty. ZL originates inside the Jovian orbit; since the Galilean satellites in eclipse shield all light beyond the Jovian orbit, they should be detected as ‘dark spots’ if the strong EBL implied by previous observations exists. The intensity deficit of this dark spot relative to the surrounding sky directly measures the brightness of EBL, free from any assumptions about ZL. The observational condition for EBL is perfect at JWST Cycle-1 season because Jupiter locates at high Galactic latitude (l> 40 deg) and deep eclipses will occur, which is the opportunity once in 6 years. Therefore, observations in this Cycle-1 are highly required.
At what redshifts and mass scales does the galaxy population transition from irregular clumpy structures, to ordered thin disks of the modern Hubble sequence? What are the roles of accretion and feedback, which regulate the gas supply and star formation in galaxies, in driving this transition?

Addressing these questions requires kinematic data for galaxies during their formative epochs, via spatially resolved spectroscopy on kpc physical scales. While progress has been made using integral field spectrographs coupled to adaptive optics (AO) systems, these ground-based efforts are limited in both sample size and accessible redshift range. In particular AO systems are unable to reach key diagnostics at the transformative period z~1 when thin disks first emerge. This proposal will chart the kinematics of 40-50 galaxies at z~1, along with resolved star formation and metallicity to understand how the formation of thin disks is governed by gas accretion and feedback.

We propose a novel approach using slit-stepping with the multiplexed NIRSpec MSA to efficiently obtain 3-D spectroscopy for a significant sample, for which the requisite spectral and spatial resolution can only be achieved with JWST's unique capabilities. In contrast to the traditional IFU mode, slit-stepping provides equivalent data with more than 15 times higher efficiency, and is therefore the only suitable approach for building a large sample with JWST! As this represents a pilot application of the slit-stepping methodology with JWST, we commit to publicly releasing processed 3-D datacubes and software tools as a service to the community, to facilitate future programs using this approach.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02143
Program Title: The turbulent magnetized interstellar medium: looking for ambipolar diffusion in the Pleiades
Principal Investigator: Francois Boulanger
PI Institution: Ecole Normale Superieure

Magnetic fields and turbulence are two intertwined actors of cosmic evolution at the crossroad of the formation of planets, stars and galaxies. In the interstellar medium, magnetic fields are generally frozen to matter but this property breaks for dynamical timescales shorter than the ion-neutral coupling time through collisions. The resulting ion-neutral drift, known as ambipolar diffusion, is a fundamental process in ISM dynamics, because it is a major channel of turbulent energy dissipation and it redistributes magnetic flux. Observational evidence of its impact on interstellar turbulence have been so far elusive. The JWST offers the opportunity for a breakthrough, which we aim to materialize.

With NIRCAM, we propose to image the diffuse interstellar medium, illuminated by the Pleiades stars, down to physical scales (15 au) that encompass the ambipolar diffusion scale. The fluorescent line emission of H2 will be the tracer of neutral gas, and PAH emission that of ions. H2 in the diffuse interstellar medium will be mapped with unprecedented resolution and sensitivity. Our project follows-up Hubble Space Telescope observations that show striations, aligned with the magnetic field orientation, in the Pleiades nebula with structure down to the 0.1” resolution of JWST. The H2 and PAH maps are expected to show similar but somehow different structure. They will be compared statistically to find evidence of the impact of decoupling of neutrals from ions and magnetic fields, as well as of energy dissipation, on interstellar turbulence. The results promise to fundamentally transform a cornerstone in our understanding of interstellar medium physics and star formation.
Young planets hold unparalleled keys to understanding planet formation and evolution. Multiple transiting planets form the best laboratories to rigorously test theories; by scaling one planet to another in a multiple system, the host star’s uncertain history can be negated. The young (23 Myr) V1298 Tau system offers us the best opportunity to conduct such detailed studies. We propose near-infrared transmission spectroscopy observations of the transiting inflated Neptune and sub-Neptune planets, V1298 Tau b and c, to determine their absolute and relative atmospheric properties, including compositions, metallicities, carbon-to-oxygen ratios, and aerosol properties.

This project will enable comparing the chemical makeup, the formation tracers, the aerosols properties, and the evolution scenarios of two sister planets within one system. It will have major impacts because it will provide crucially needed novel observational constraints to several important areas of the field of exoplanets, including studies of planet interior, atmosphere, evolution and aerosol formation. The strength of this approach is that it will enable a direct and even comparison of planets within one system. This will be transformative since exoplanet atmospheric studies systematically suffer from comparing planets orbiting stars with often unknown histories.

The outcome of this project will shed lights on the entire population of exoplanets. It will be an important legacy for the community, and provide benchmark spectra that will enable comparative planetology studies between the targeted planets, and with other planets, young and mature, including those targeted in the JWST GTO and ERS programs.
Complex organic molecules (COMs) are precursors of pre-biotic molecules. The discovery of COMs in protostellar cores indicates an extensive chemical evolution took place in the first million years of star formation. The chemistry of COMs in the protostellar phase may directly link to the COMs in comets and the eventual planetary system. Gas-grain chemistry on the ice mantles of dust grains at warm temperature (20-40 K) has been successful to explain the abundance of COMs in the gas phase. However, observational constraints on ice composition at such temperatures have been inaccessible until JWST. Moreover, not all protostars show evidence of gaseous COMs in their spectra, suggesting either a different chemical evolution of ices or inefficient desorption that keeps most COMs on grains. Does the formation pathway of COMs proceed according to existing models? Is the chemical diversity in the gas phase rooted in ices? To answer these two questions, we will use JWST to measure the ice composition, particularly from warm temperatures (20-40 K) to the desorption temperature. The MIRI MRS observations will probe the ice composition around the protostar at 20 K or higher temperature to (1) measure the ice composition at warm temperatures (>20 K) to test chemical models of COMs, (2) spatially resolve the ice variation at the same scale where gaseous COMs are detected, and (3) determine the origin of chemical diversity from the ice composition of both COM-rich and COM-poor protostars within similar properties.
To directly confront planet formation mechanisms, a sample of objects in the earliest stages of their lives, i.e., when they are still embedded in their natal protoplanetary disks, need to be observed and studied. Here we propose to demonstrate a synergistic approach between the Atacama Large Millimeter/submillimeter Array (ALMA) and the James Webb Space Telescope (JWST). ALMA observations can reveal the location of an embedded planet by its influence on the dynamical structure of the protoplanetary disk, while the strength of these perturbations allow for a tight constraint on the mass of the planet. Here we propose to image for the first time an embedded planet in the disk around HD 163296 using the MIRI instrument onboard JWST. The 2 M\textup{Jup} planet has been detected in several, independent studies and lies 2\textup{''} north of the host star. JWST/MIRI in coronagraphic mode at 11.4 $\mu\text{m}$ is the only available option to detect such embedded objects for decades to come, as no other instrument has the mid-infrared high-contrast capabilities necessary to overcome the obstacle of disk absorption prevalent at shorter, NIR wavelengths. Given its mass and separation, the planet around HD163296 offers the highest chances of detection and would pave the path for a new and highly efficient exoplanet detection method. Detecting emission from the planet and its surrounding is going to reshape our understanding of planet formation, allowing for direct comparison between formation scenarios.
Interstellar dust influences the physics of the gas in galaxies because it affects cooling and molecule formation. Understanding the nature of interstellar dust in galaxies is thus crucial for understanding the evolution of gas and stars in galaxies. Unfortunately, the composition and structure of dust grains in distant galaxies is not well understood. Recently a number of gas-rich galaxies with strong 2175 Å bumps have been discovered in absorption along the lines of sight to distant quasars. Here we propose a JWST MIRI spectroscopic study of 8 such gas-rich and dusty galaxies at redshifts 0.5 < z < 1.2 for the first comprehensive study of dust composition in these distant galaxies. The proposed MRS spectra will target the 10 micron silicate absorption feature, the 3.4 micron hydrocarbon absorption feature, and the 3.1 micron water ice absorption feature. Our scientific goals are: (1) to examine whether the presence of the 2175 Å bump is correlated with the presence of 10 micron silicate absorption, and whether any trends exist between the abundances of silicate and carbonaceous grains; (2) to determine the composition of silicate grains; (3) to investigate whether the carrier for the 2175 Å bump is related to that for the 3.4 micron feature; and (4) to examine whether enough O can be locked up in H2O ice in these galaxies to address the "missing oxygen problem" for dust grains. JWST MIRI alone can provide the necessary combination of mid-IR wavelength coverage, exquisite sensitivity, and spectral resolution essential for efficiently observing the desired mid-IR dust features in the proposed sample of distant galaxies located along the sight lines to quasars.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02158
Program Title: From East to West: the first simultaneous temperature and cloud map of a hot Jupiter.
Principal Investigator: Vivien Parmentier
PL Institution: University of Oxford
CoInvestigators
Everett Schlawin University of Arizona, Michael Line Arizona State University, Jake Taylor University of Oxford, Thaddeus Komacek University of Chicago, Megan Mansfield University of Chicago, Kevin Stevenson The Johns Hopkins University Applied Physics Laboratory, Jonathan Fortney University of California - Santa Cruz, Peter Gao University of California - Santa Cruz

With the discovery of 51 Peg b in 1995, hot Jupiter atmospheres have challenged our understanding of atmospheric dynamics. Infrared phase curves observed by Spitzer and Hubble have shown positive offsets, meaning that the hottest point of the atmosphere is shifted east of the substellar point. On the other hand optical phase curves observed by Kepler have shown negative offsets, meaning that the coldest part of the planet is shifted west of the substellar point. This anti-correlation between temperature and cloud map can provide strong insights into the cloud formation process in hot Jupiters. However it relies on observations carried on two different population of planets with two different instruments.

We propose to observe the full orbit phase curve of NGTS-10b simultaneously from the optical to the infrared using the unique capability of the NIRSpec/PRISM instrument. We will observe the peak of the phase curve continuously shift from a negative to a positive offset on a given planet for the first time. We will map the longitudinal, latitudinal and heigh variation of the cloud, the chemical abundances and the thermal structure of the planet. We will detect chemical disequilibrium on the planet nightside and determine the condensation temperature of the clouds.

By combining optical and infrared phase curves we will create the first isobaric map of a hot Jupiter, a necessary step to benchmark current theoretical models. This will be crucial to inform which level of complexity will be required in future atmospheric retrieval models to obtain unbiased abundances measurements from secondary eclipse and transit observations of hot Jupiter atmospheres with JWST.
The relatively rare sub-population of the so-called ultra-short period (P < 1 day) rocky planets offers a unique opportunity for atmospheric characterization studies. Given the large amount of stellar irradiation these planets are bombarded with, they are expected to have lost their primordial atmospheres giving rise to thin or thick (i.e., low or high pressure) outgassed, exotic Na, O or SiO-rich atmospheres. Characterizing the surfaces and/or atmospheres of these highly irradiated rocky worlds, thus, provides a window to explore exciting atmospheric and/or surface compositions which might be completely different to the ones observed in our Solar System. Motivated by these fascinating prospects, here we propose to constrain the atmosphere of the ultra-short period (6.9-hour; $T_{\text{eq}} = 2150$ K) transiting super-Earth K2-141b ($R_p=1.51\text{REarth}; M_p=5.08\text{MEarth}$) through a spectroscopic phase-curve observation with the James Webb Space Telescope. Our program, which will allow us to directly detect the thermal emission of this exoplanet as a function of both orbital phase and wavelength, will provide precious insights into its atmospheric and/or geological properties, which will serve as a strong leverage for future studies and characterization efforts of highly-irradiated super-Earths.
It is not well understood how massive galaxies regulate their star formation, and hence inhibit rapid conversion of their gas into stars. Both AGN feedback and feedback from the star formation process itself are likely to contribute. The radio galaxy 3C 326N is a key target in resolving this issue because it contains a large mass of warm molecular gas that appears to be prevented from forming stars by large turbulent motions (seen in line widths of ~ 600 km/s on 1.0” scales), and that cannot be related to the AGN radiation, which is very faint. We have proposed that the turbulent motions are powered by the kinetic energy of the radio outflow, and that this is sufficient to inhibit star formation for 10^8 yr or longer. We now propose to measure the turbulent motions of the warm molecular gas at the diffraction limit of the JWST with NIRSPEC, which cannot be reached with ground-based adaptive-optics-assisted IFUs for this source. A central prediction for turbulent gas is that the line widths will remain high, FWHM~60 km/s down to these scales where, in absence of jet-driven turbulence, the gas should otherwise become gravitationally unstable and start to form stars. This is a simple observational test of a single source, which represents a direct test of a mechanism that has been proposed to be a universal process regulating star formation in galaxies, but which is extremely challenging to observe in more complex systems, where star formation, AGN radiation, and radio jets co-exist. Demonstrating its validity even in a single object will therefore be an important complement to the large number of studies of warm H2 in active galaxies that MIRI will enable.
An efficient coupling between the energy released by Active Galactic Nuclei (AGN) and the interstellar medium (ISM) of their host galaxy can generate kpc scales outflows which may regulate the rate at which stars can form and ultimately influence the growth of the galaxy. These AGN-driven outflows include gas in various phases (ionized, atomic, molecular) but at z>1, due to the limitations of current instrumentation, we are forced to adopt a single-phase (ionized) view of the outflow phenomenon which may lead to wrong estimates of their extent, mass and energetics, therefore ultimately misinterpreting their relevance for galaxy evolution.

The aim of the proposed JWST/MIRI observations is to overcome this limit, and to map the mid-infrared ro-vibrational H2 lines to complete the multi-phase characterization of already well-studied AGN at cosmic noon. The three selected AGN have the best available characterization of the ionized component of the outflow at these redshifts, from sub-pc to kpc scales. With the MIRI observations we will be able to map the warm component of the ISM down to ~2 kpc. We will be able to test model predictions on the enhancement of H2 emission in the presence of cooling of gas shocked by AGN-driven outflow. Ultimately, we will derive the total (ionized +molecular) mass outflow rate and kinetic energy for these outflows which will provide a key constrain on the current models of AGN feedback.
Proposal Category: GO  
Scientific Category: Intergalactic Medium and the Circumgalactic 
ID: 02180  
Program Title: Structure formation and baryonic cycling in the edge-on galaxy NGC891  
Principal Investigator: Ilse De Looze  
PI Institution: Universiteit Gent  
Co-investigators  

Due to their inclined orientation, local edge-on galaxies provide unique laboratories to study vertical disk stratification and to probe the extent and the composition of the circumgalactic medium. One of the major challenges that current galaxy evolution models face involves properly characterising the efficiency of various feedback mechanisms in regulating galaxy's vertical disk scaleheights and in driving feedback-driven outflows. With our proposed high-sensitivity JWST observations of the nearby edge-on galaxy NGC891, we aim to (1.) resolve the vertical galaxy disk layering of stars and dust, and search for heavily observed star clusters with NIRCAM (F150W, F277W); (2.) probe the distribution and anisotropy of dust (MIRI F770W, F1000W, F1130W) and molecular gas (MIRI MRS IFU) in the circumgalactic medium, and link extraplanar chimneys of gas and dust to the heavily embedded star formation activity in the disk to constrain the efficiency of radiative and mechanical feedback mechanisms driving gaseous outflows; (3.) constrain the photo-ionisation sources (and pressure) and its variations with scaleheight in the extended diffuse ionised gas layer at two radial positions R=0kpc and R=10kpc (MIRI MRS IFU). Together, these JWST constraints on the vertical stellar disk structure, extraplanar gas and dust distribution, and the diffuse ionised gas layer will provide a unique set of constraints to test prescriptions of various feedback mechanisms and "bathtub" gas regulation in highly resolved (~1pc) simulations of patches of galaxy disks. These high-resolution simulations will lead to improved subgrid models for the next generation of large-scale cosmological simulations.
Dust in the diffuse interstellar medium (DISM) is a major contributor to the energy balance and chemistry of interstellar gas and dust in galaxies. The DISM is fed by chemically diverse, partially crystalline stardust produced by evolved stars and supernovae, but amorphized and destroyed by interstellar shocks and radiation at rates that significantly exceed production. We therefore lack a fundamental understanding of the dust cycle in galaxies and its main elemental building blocks: C, O, Si, Mg, and Fe. We propose to use JWST’s unique combination of wavelength coverage, sensitivity, and spectral resolution at near- and mid-infrared wavelengths to measure the abundance and determine the composition of the major C and O dust reservoirs in the Milky Way’s DISM. We will detect the absorption fingerprint of DISM dust along carefully selected sightlines toward well-characterized background OB stars which lack strong ice features indicative of dense molecular cloud environments. This will allow us to answer several long-standing questions in the cycle of dust in galaxies, namely: what is the composition and lattice structure of DISM silicates? what is the nature of interstellar carbon dust? and what is the location of the missing oxygen in the DISM? Addressing these questions is of fundamental importance, because the DISM is the starting point for star and planet formation, setting the initial conditions for material that feeds into molecular clouds.
The aim of this proposal is to investigate a recently suggested hypothesis of high-density starburst in ULIRGs. This hypothesis stems from systematic observations of Br-alpha (4.05 microns) and Br-beta (2.63 microns) lines in ULIRGs conducted by the space infrared telescope AKARI. The observed Br-beta/Br-alpha flux ratio exceeds the upper limit of the well-known Case B and corresponds to apparently negative extinction. This suggests that Case B no longer holds in the star-forming regions of ULIRGs and that due to an extreme number density as high as 10^8 cm^-3, the Br-alpha line is optically thick and saturated. To test this hypothesis, NIRSpec IFU observations are proposed to follow up the five ULIRGs that showed anomalous Br-beta/Br-alpha ratios. By examining the spatial distribution of Br-beta/Br-alpha the site of the harsh star-formation can be investigated. This Br-beta/Br-alpha anomaly is not only a critical issue to understand the star-formation in ULIRGs but also a challenge to the fundamental method in astronomy that measures the star formation rate and dust extinction from recombination lines. These Br-alpha and Br-beta lines cannot be observed from the ground, and the new channel provided by JWST will make this science possible for the first time.
Quantifying the nature and prevalence of the recently-discovered extremely-red galaxies found in Spitzer IRAC data, but not seen by Hubble, is one of the most exciting high-redshift opportunities for JWST's infrared capabilities. These galaxies are suspected of being either dusty star-forming galaxies at z~3-6, or, most intriguingly, quiescent evolved galaxies at z~4-5. These "H-dropouts", so-named from their non-detection by Hubble's WFC3/IR camera, remain an enigma. The limited spectral coverage of the current photometric data has precluded any reliable assessment of their redshifts. And spectroscopic confirmation has been quite impractical. ALMA data has provided further confirmation, but without establishing redshifts. H-dropouts pose significant challenges to galaxy growth models (if evolved), or to our estimates of the history of galaxy build-up (if dusty star-forming). Our JWST "H-drop" pilot program uses NIRSpec/prism spectroscopy at R=100 to reveal the true nature of these extremely red galaxies. We have identified two relatively bright, plausible z~4-5 quiescent galaxies from the deepest IRAC imaging data of the GOODS-S field, plus a larger sample of H-band undetected sources in that same field. Our primary goals are to: (1) obtain the first spectroscopic redshift measurement for this enigmatic population; (2) distinguish quiescent from dusty star-forming sources; (3) constrain their physical properties including gas-phase metallicities; (4) provide new measurements for the contribution of obscured sources to the cosmic Star Formation Rate Density at z~3-6; and (5) possibly confirm the first quiescent galaxies at z~4-5. Only JWST/NIRSpec can achieve these goals.
The main objective of this proposal is to observe the center of the globular cluster NGC6440, with the aim of detecting the companion to the PSR J1748-2021B binary pulsar. This pulsar is suspected of having a mass of about 2.5 solar masses, but this value can only be confirmed if we can estimate the mass of the companion star. Detecting a low-mass companion would confirm the large pulsar mass, establishing that neutron stars can be stable at these high masses. This would have fundamental consequences for the study of the equation of state of cold, dense neutron matter and for nuclear physics. This would also have broad impact on astrophysics, indicating, for instance, that a significant fraction of NS-NS mergers leave behind stable neutron stars, which might be detectable in future EM observations. It would also shed light on the nature of the highly asymmetric GW190814 LIGO/Virgo merger event, where a 23 solar-mass black hole merged with a lighter 2.6 solar-mass object that is currently in the mass gap between the lightest black holes and the most massive neutron stars.

The proposed observations will very likely detect the counterpart assuming it is a low-mass main sequence star or white dwarf; this would allow an estimate of the mass of the companion and the mass of the pulsar. A non-detection would indicate that the companion is a compact object, in which case we would be unable to constrain the component masses.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02209
Program Title: Preparing for planets: the impact of the extraordinary outburst of EX Lup on its circumstellar disk
Principal Investigator: Peter Abraham
PI Institution: Konkoly Observatory
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The extraordinary outburst of the young eruptive star EX Lup in 2008 offers currently the best and only opportunity to study quantitatively the effect of a pre-main sequence outburst on the circumstellar disk. Mid-infrared spectroscopic observations during the burst revealed the formation of crystalline silicates, as well as drastic chemical changes in the abundances of gas-phase OH, H₂O, and organic molecules. Observations suggest, and simulations make predictions for the outward transport of the fresh crystals and for the timescales and intensity of molecular changes. Here we propose to use JWST/MIRI in medium resolution spectroscopy mode to re-discover the lost crystalline grains 15 years after the outburst. We will measure their mass, pinpoint the outward transport trajectory, and learn if the crystals could have reached the comet-forming zone behind the snowline, solving the mystery of the measured high crystallinity in solar-system comets. The spectra will also provide unique information on the time-dependent outburst-induced chemistry, and enables us to decide whether molecular reformation leads to long-term cumulative changes in the chemical content of the inner disk. EX Lup is the only target to answer these questions, because precise observations exist for pre-burst, burst, and - with JWST - the post-outburst phases. The project will close the investigation of the 2008 outburst, and provides a quantitative assessment of the effects of similar outbursts, which the proto-Sun also could have experienced, on the chemical and mineralogical inventory of the inner disk where terrestrial planets and comets form.
Asteroids act as dynamical and chemical tracers of the formation and evolution of our Solar System. The history of water in the Solar System is fundamental, both cosmochemically and astrobiologically, and observing water on asteroids helps constrain the story of our planetary system and of life on Earth. However, until now, this has been a very challenging endeavor. The most prominent hydration feature present on asteroids is found near 3 microns. This wavelength region is difficult to observe from Earth because water in the Earth’s atmosphere makes that spectral region nearly opaque. We propose here to carry out a pure parallel survey to measure the fraction of main belt asteroids that are water-bearing. We will observe around 100 asteroids with sizes as small as 100 meters. We will measure the fraction of asteroids with hydration features larger than around 10%, and derive the amount of water present in the asteroid belt. A pure parallel project with JWST is the only way to carry out this experiment, with its implications for the formation and evolution of our Solar System and life on Earth. Our expected sensitivity is well matched to LSST, so all objects that we observe will, in a few years, also have known orbits, colors, taxa, and lightcurves.
Molecular gas is a critical ingredient in the recipe of star formation (SF) in galaxies. In order to fully understand the processes that govern SF, it is essential to accurately measure, map and characterize the distribution of H2 in star-forming environments. Since H2 is a weak rotational emitter, the molecular gas content in galaxies is typically inferred using indirect tracers. The CO (1-0) transition has been widely used as H2 tracer for decades. However, CO provides a partial census of the total H2 mass, particularly in regions with large quantities of CO-dark gas. Recent evidence from an FUV spectroscopic study suggests that S+ might be tracing large amounts of CO-dark gas in the core of M83. Here we propose to exploit the unprecedented capabilities of JWST in the MIR, using the MIRI/MRS, to perform a spatially-resolved study of the warm H2 gas in the heart of this face-on spiral galaxy. Our motivation is to directly detect the warm H2 in the core of M83, and infer the total H2 mass by combining the spatially-resolved data with a new continuous-temperature model using the H2 rotational emission. Ultimately, we will be able to test if S+ indeed trace CO-dark gas in such environments with intense SF. To understand the fueling SF history through cosmic time, it is imperative that we test and develop tools to accurately estimate molecular gas mass directly probing the H2 reservoirs. JWST, with its unrivaled sensitivity will allow us to do exactly that.
The Milky Way's Central Molecular Zone (CMZ) is a local analogue to the star-forming environments at the peak of cosmic star formation (z ~ 2). Under these conditions, CMZ clouds are forming stars at a rate lower than expected given their large reservoirs of dense gas. Two clouds in particular, The Brick and Cloud C, are prime examples of this, with no evidence of widespread star formation despite their extreme masses and densities. We propose to use JWST to pierce through these dark clouds to obtain a census of the embedded YSO population and to uncover recent and ongoing low-mass star formation. Because of the relative locations of The Brick and Cloud C, MIRI will be pointed at Cloud C while NIRCam is pointed at The Brick and vice-versa. Therefore, we propose coordinated parallel observations where MIRI will search for the most deeply embedded YSOs based on their 25 micron dust emission while NIRCam will search for direct accretion signatures using the hydrogen recombination lines, H2, and CO filters. The PaAlpha and BrAlpha filters will identify the ionized flows of accreting sources, while the H2 filter shows outflow shock knots, and the CO band will exhibit either ice absorption from the cold envelope or disk emission from hot inner disks. We will use our sample of YSOs to map out the recent star formation history of these clouds and test competing theories for cloud evolution and star formation stochasticity in the CMZ.
The central black hole (BH) of the giant elliptical galaxy M87 has been studied for more than 40 years. Similar to Sgr A* at the Galactic Center, the remarkable increase in angular resolution over the years, culminating in the Event Horizon Telescope image of the M87 BH shadow, has paved the way for a deeper understanding of the compact object and the immediate surrounding environment. The EHT image also provided an independent measurement of the M87 BH mass, which is consistent with the most recent stellar-dynamical result but differs by a factor of ~2 from the gas-dynamical determination. On the surface, the agreement between the EHT and most recent stellar-dynamical BH mass provides an important validation of the stellar-dynamical technique, but it is pressing to scrutinize the apparent agreement further because both measurements relied on extensive modeling and built-in assumptions. We propose to acquire the best high angular resolution spectra to date at the center of M87 using the NIRSpec integral field unit (IFU). We will study parsec-scale stellar dynamics around the M87 BH and extract reliable kinematics deep within the BH gravitational potential. When combined with existing large-scale IFU stellar kinematics and a new, fully general, triaxial, orbit-based modeling approach, we will obtain the most robust stellar-dynamical BH mass for M87. We will further carry out a comprehensive analysis of the error budget, incorporating possible systematic effects. M87 is a pivotal anchor for the upper end of the BH mass - host galaxy relations, and it is crucial to obtain the best possible BH mass measurement.
Vertical mixing in giant planet and brown dwarf atmospheres controls crucial aspects of cloud thickness and particle sizes, the transport of molecules into the stratosphere, and deviations from equilibrium chemistry. Unfortunately, the fundamental atmospheric parameter used in modeling these processes, the vertical eddy diffusion coefficient ($K_{zz}$) is unknown to within many orders of magnitude. However, it is now apparent that precision atmospheric abundances of non-equilibrium chemical species, which will be delivered by JWST spectra, can be used to constrain $K_{zz}$ to a level not previously appreciated. At the same time, a variety of new 1D and 3D theories have been put forth to predict $K_{zz}$ in radiative regions, to complement mixing length theory in convective regions. We aim to put the breadth of these theories to the test by coupling them to a 1D radiative-equilibrium atmosphere code to predict non-equilibrium atmospheric abundances and spectra that can be directly compared to forthcoming JWST spectroscopy of transiting planets, imaged planets, and brown dwarfs. The outcome of the synergy of JWST observations with these models will be orders of magnitude better constraints on $K_{zz}$, by far the most poorly known parameter in giant planet and brown dwarf atmospheres, enabling significantly better interpretation of JWST observations.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02234
Program Title: The JWST-legacy narrow-band survey of H-alpha and [OIII] emitters in the epoch of reionization
Principal Investigator: Eduardo Banados
PI Institution: Max-Planck-Institut fur Astronomie, Heidelberg

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Star-forming galaxies in the first billion years of the Universe (z>6) are thought to be responsible for reionizing the intergalactic medium. To date, only a dozen galaxies that are well within the reionization era are spectroscopically confirmed, leaving the earliest star formation in galaxies virtually uncharacterized. One of the most efficient ways to identify star-forming galaxies is through narrow-band imaging surveys. Before JWST, only Ly-alpha narrow-band surveys were possible at z>6, but this is the cosmic epoch where the increasingly neutral intergalactic medium makes it difficult to detect Ly-alpha. We propose a ~100arcmin2 NIRCam narrow-band F470N (+F090W) survey to unambiguously identify H-alpha emitters at z~6.2 and [OIII] emitters at z~8.4, both within the reionization era. Unlike Ly-alpha, these lines are not affected by a neutral intergalactic medium. Our survey is designed to map the same NIRCam area covered by the Cosmic Evolution Early Release Science (CEERS) survey, which also has myriad existing, deep, multi-wavelength observations (e.g. HST, Chandra). We will identify H-alpha and [OIII] emitters with star-formation rates >5 and >4 Msun/yr, respectively. We will provide crucial estimates of the instantaneous star formation rate, number density, luminosity function, sizes and morphologies of star-forming regions, and clustering of star-forming galaxies in the epoch of reionization. In addition, we will deliver contamination rates applicable to other studies without the wealth of information available for this particular field. This survey will have an enormous legacy value and will become a reference comparison sample for many JWST high-z studies.
We propose to monitor the near-IR flare emission of Sgr A* at two wavelengths using NIRCam imaging. The observations will consist of 2 12-hour episodes to be carried out simultaneously with observations by ALMA and the Event Horizon Telescope (EHT). Simultaneous measurements at 2.1 and 4.8 microns provide the spectral evolution of IR flare emission. This yields information about the particle acceleration process and subsequent synchrotron cooling of the highest-energy particles. Using an adiabatic expansion model, the IR light curve can then be used to determine the spectrum and the variability of submm emission across the multiple flares that are likely during the course of the EHT observations. The predicted submm variability is a necessary component in being able to construct an image of the black hole shadow from the EHT observations. The proposed simultaneous IR and submm observations of the variability of Sgr A* will be key to the EHT's success.
We will collect the first direct images of a radial velocity planet, by targeting Eps Indi Ab with JWST/MIRI. This recently discovered Jovian mass exoplanet has been identified with long-term radial velocity and astrometry measurements, around a star at just 3.6pc. The planet has mass 3.3Mjup and semi-major axis 11au, and at an age ~4Gyr the planet is ~200K, far colder than any directly imaged planet to date. Our simulations confirm that we will detect Eps Indi Ab’s thermal emission at high confidence, regardless of its cloud properties or thermal evolution.

Eps Indi Ab provides a unique opportunity to measure both the luminosity and the dynamical mass of a true Jupiter-analog, with a well constrained age. We will image the system in two filters, and thereby derive a constraint on the temperature and cloudiness of the system. The system is also particularly interesting in the context of planet formation: Eps Indi A is co-moving with the low mass binary brown dwarf Eps Indi BA/BB. The planet and brown dwarfs have similar ages and formed in similar environments, but have very different masses, making this an excellent benchmark system for formation models.

This project will pave the way for future studies of this system: the flux and orbital constraints derived here will allow complex observations, such as MIRI medium resolution spectroscopy or variability studies, in future cycles. As the closest Jupiter analog to the Solar System, Eps Indi Ab will be the highest-priority target for comparative studies of cold gas giant atmospheres for the foreseeable future. That long-term legacy starts here with the first mid-infrared characterization of the planet spectrum.
The discovery of z>7 quasars hosting billion solar mass supermassive black holes (SMBHs) places the strongest constraints on the formation of the earliest SMBHs in the universe. These quasars are also signposts of the assembly of the early massive galaxies during the epoch of reionization. Is there an upper limit on BH masses and the rate of their growth in the early universe? Recently, a luminous quasar at z=7.1 has been discovered to host a SMBH with at least 10 billion solar masses. It also shows evidence of strong dust reddening based on ground-based spectroscopy. Its rest-frame UV continuum shape is highly unusual, suggestive of extinction due to supernova produced dust. However, the total extinction is completely unconstrained with ground-based data, therefore the SMBH mass is only a lower limit. We propose to carry out JWST observations to obtain its rest-frame optical spectrum and broad-band SED in the near-infrared. The first goal is to accurately measure its BH mass based on its H-beta line and bolometric luminosity fully corrected for extinction, in order to confirm the first detection of a BH with mass exceeding 10 billion solar masses in the early universe. The same data will be used to characterize the nature of dust extinction and test whether supernova dust can explain its continuum shape. The modest JWST program proposed here will unveil the nature of this remarkable quasar at the epoch of reionization, and provide new insight in the growth of the most massive BHs in the early universe and their connections to galaxy formation.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02260
Program Title: Caught in the act of dispersing their disks? MIRI MRS can tell
Principal Investigator: Ilaria Pascucci
PI Institution: University of Arizona
CoInvestigators
Uma Gorti SETI Institute, Giulia Ballabio University of London, Queen Mary & Westfield College (QMWC), Cathie Clarke University of Cambridge, Andras Gaspar University of Arizona, Richard Alexander University of Leicester

Transition disks are planet-forming disks with large dust gaps or cavities, from a few to tens of au. Based on spectrally resolved 12.8 micron [NII] profiles, several of them have been also found to drive slow (~5 km/s) winds, compatible with star-driven photoevaporative flows. Regardless of whether the gaps/cavities are created by planets or photoevaporation, these systems might be in the unique stage of dispersing their disks. However, line profiles alone cannot exclude MHD winds which might drive evolution but not dispersal. Here, we propose MIRI MRS observations of two transition disks with a large dust cavity (>30 au in radius) and a small (<=4 au) inner disk plus evidence for a slow [NII] wind. MIRI MRS is the only instrument that can spatially resolve [NII] emission near or exterior to the cavity radius as expected in the photoevaporative wind scenario. Along with [NII], we will map the emission from other forbidden and H recombination lines to constrain the ionization fraction of the flowing gas, hence wind mass loss rates. Our project will establish how much time is left for planet formation and migration in these two systems and provide a pathfinder for future observations aiming at clarifying how disks disperse.
Ice is an essential ingredient in both the initial formation process of planets and for setting planets' initial compositions. However, the distribution of ice during planet formation is currently poorly constrained. We propose to map the 3.1 micron H2O ice feature in the outer regions (>53 au; 0.735") of the fascinating V4046 Sgr protoplanetary disk system. The primary goal of this proposal is to localize the spatial extent of the H2O ice disk, to shed light on ice abundances and transport during planet formation. Ground-based coronagraphic imaging reveals >39 stars within the boundaries of V4046 Sgr's gas-rich disk (4" CO radius), making it an ideal target for an ice study. We plan to map V4046 Sgr's ices spectro-photometrically using NIRCam coronagraphic images covering 1.82 -- 4.3 micron, allowing us to fit the 3.1 micron absorption depth to pinpoint the presence of ice. We expect to detect both ice absorption against the background stars and reflected light from the disk, if ice is present. These two constraints offer complimentary approaches to examine both surface and midplane ice populations, allowing us to produce the first three-dimensional ice map of a planet-forming disk.
Models of cosmic reionization predict that the earliest star-forming systems develop in primordial overdensities which, in turn, create ionized bubbles. With time, these bubbles grow and coalesce until the intergalactic medium is fully ionized. Since Lyman-alpha photons originating in these protoclusters can propagate freely through ionized gas, the highest redshift Lyman Alpha emitters (LAEs) act as valuable tracers of early ionized bubbles. We present evidence that the highest redshift LAE, EGSz8p7 (z=8.68), is likely embedded in such an overdensity. Collectively, in all of HST's deep fields, blank fields and gravitationally-lensed fields spanning >1000 arcmin^2 there are ~30 photometric candidates at z~9, yet a third lie within 3.75' (10 cMpc) of EGSz8p7. To confirm and exploit this extraordinary early overdensity we seek systemic redshifts and diagnostic features only JWST can provide. We propose blind, grism spectroscopy to map the ionized bubble around EGSz8p7 using the [OIII] doublet. A blind survey is optimal for determining a complete census of EGSz8p7's physical neighbors. Spitzer/IRAC color excesses at z>8 imply extreme [OIII] EWs (~6000 A) ensuring efficient use of JWST. Stellar population modeling of the sources around EGSz8p7 may give us the strongest constraints yet on when star-formation first commenced after the Big Bang (i.e., cosmic dawn). Our spectra will likewise constrain the ionizing photon production efficiency, a key unknown in reionization calculations. Our observing strategy is designed for maximum legacy value with a footprint overlapping the CEERS ERS survey and use of the wide F444W grism that will guarantee additional 1<z<9 science.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02282
Program Title: A Strongly Magnified Individual Star and Parsec-Scale Clusters Observed in the First Billion Years at z = 6
Principal Investigator: Dan Coe
PI Institution: Space Telescope Science Institute - ESA

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JWST was designed to study the first stars. Until recently, we assumed that meant populations of stars within the first galaxies. But in the past 3 years, 3 individual strongly lensed stars have been discovered at z~1. This offers a new hope of directly observing individual stars at cosmological distances with JWST. Here we propose JWST observations of a candidate strongly lensed star at z~6, dubbed LSz6. For the past 3 years, LSz6 has been steadily magnified by a factor of ~9000 on the lensing critical curve directly between multiple images of a bright star forming clump. The clump is also remarkable as the most distant known bound massive star cluster, with a radius < 6 pc, the size of local star clusters. This unprecedented spatial resolution is afforded us by the most highly magnified z=6 galaxy known, dubbed the "Sunrise Arc".

We propose 3 hours of NIRCam imaging in 2 epochs and 3 hours of NIRSpec MOS PRISM spectroscopy of 12 positions along the arc. These observations will:

1) Confirm LSz6 is an individual star at z=6 and place it on the H-R diagram with measurements of luminosity and temperature

2) Confirm the lensed clumps are bound massive star clusters, constrain their histories and fates, and measure their individual ionizing strengths

3) Confirm the existence of a galaxy core and measure outward gradients of mass, metallicity, and age for the first time in detail at z=6

Observations from this program will inform future JWST proposals to study the Sunrise Arc in even greater detail and provide time monitoring for years to come. We waive exclusive access to all data obtained from this program to benefit the community.
Proposal Category: GO  
Scientific Category: Galaxies  
ID: 02285  
Program Title: A massive quiescent galaxy at redshift 4.657  
Principal Investigator: Adam Carnall  
PI Institution: Royal Observatory Edinburgh  
Col Investigators: Ross McLure Royal Observatory Edinburgh, James Dunlop University of Edinburgh, Institute for Astronomy, Andrea Cimatti Universita di Bologna, Vivienne Wild University of St. Andrews, Fergus Cullen Royal Observatory Edinburgh, Derek McLeod Royal Observatory Edinburgh, Massimiliano Hamadouche Royal Observatory Edinburgh, Ryan Begley Royal Observatory Edinburgh, Sam Walker University of Edinburgh, Institute for Astronomy

We propose ultra-deep rest-frame UV-optical spectroscopy of the earliest robustly identified massive quiescent galaxy. Our target, GOODSS-9209, has a stellar mass of $10^{11}$ Solar masses, a star formation rate (SFR) suppressed by at least 1 dex below the star-forming main sequence, and a spectroscopic redshift of 4.657, placing it just 1.25 Gyr after the Big Bang. This object provides a unique perspective on galaxy evolution during the first billion years, holding the key to understanding when and how baryonic feedback processes first began to arrest the extremely intense star formation observed in the earliest galaxies.

By observing H alpha at 3.7 microns we will precisely measure the SFR of GOODSS-9209. If no star formation is detected, as suggested by photometric studies, this would be the first clear evidence that a passively evolving galaxy population exists as early as z~5. Alternatively, as this is the most firmly identified quiescent galaxy at z~5, a detection of residual star formation would strongly imply no galaxies have completely quenched by this epoch, and could indicate we have caught one of the first quenching events in progress.

GOODSS-9209 is known to have been quiescent for 300 Myr, however its prior evolution is unknown. Through spectral fitting we will measure the full star-formation history (SFH), stellar metallicity and alpha enhancement. A bursty SFH, combined with high metallicity and alpha enhancement would confirm this object formed rapidly as a submillimetre galaxy, showing such events can result in sustained quiescence. This inexpensive yet extremely high impact science case provides an ideal demonstration of the unique capabilities of JWST.
We will obtain R~2700 spectra from 1-28 $\mu$m of two ~L6 brown dwarfs with S/N~100 or better shortward of 10 $\mu$m. In existing IRS spectra, 2MASS 2148+4005 has a broad 8-10 $\mu$m absorption feature suggestive of silicates, while the otherwise similar 2MASS 0624-4521 has weak silicate absorption at best. We will use these spectra to distinguish sharp molecular features from broad absorption (e.g., due to silicates), to study cloud formation in L dwarfs, to detect trace species that would be diluted at low resolution, to probe different layers in the photosphere, to constrain physical properties, to uncover deficiencies in atmosphere models, and to identify flaws in existing opacity data (e.g., line broadening). We encourage rapid independent analysis and publication of these data by the community to provide a strong foundation for the next round of observing proposals.
Beta Pictoris is a unique laboratory for studying the formation of giant exoplanets. The system contains two directly imaged planets with dynamically inferred masses, therefore it is a treasure for comparative exoplanetology and calibration of planet formation and evolution models. The presence of the second planet, which was discovered through radial velocity measurements, has recently been confirmed with GRAVITY at a separation of 2.7 au. Since beta Pic b orbits at 9.8 au, this system resembles a young and more massive instance of the giant planets in our Solar System. The K band spectrum indicates that beta Pic c is cooler and smaller than beta Pic b but the chemical characteristics of beta Pic c remain unknown. We propose NIRISS/AMI observations at F380M, F430M, and F480M to quantify the atmospheric composition of beta Pic c. At these wavelengths, we will be sensitive to the carbon content of the atmosphere which, together with the available K band spectrum, will enable us to set unique constraints on both the carbon-to-oxygen ratio and the metallicity of beta Pic c. Additionally, the extended wavelength coverage of the spectral energy distribution will allow for a more accurate measurement of the radius and bolometric luminosity. Altogether, the proposed observations provide us with the exciting opportunity to study for the first time the chemical composition of a giant exoplanet at an orbital separation comparable to Jupiter. The combined constraints on the chemical composition and the macrophysical properties will unveil important clues about the formation history of beta Pic c.
Galaxy evolution models are strongly underpinned by anchoring constraints made locally in the Milky Way. In this proposal, we aim to perform a pilot study toward providing a secondary local anchor in the form of a detailed mapping in element abundances of the stellar populations of the Andromeda galaxy, M31. Primarily, we will use NIRSpec spectroscopy of giant stars to study element abundances in the old disk of M31, establishing whether it plays host to a dichotomy in the ratio of its alpha-element abundances relative to Iron. Such a feature is readily observed in the Milky Way, and thought to be indicative of an early and rapid assembly of its mass. These pilot observations towards larger spectroscopic surveys of the M31 disk will allow us to discriminate between the myriad models which are now proposed for the origin of this feature in the Milky Way. This will place the first stake of true galactic archaeology in Andromeda, opening the door to more detailed future studies which will attempt to reconstruct the star formation history and more fully constrain the history of mass assembly in our nearest giant disk.
The understanding of the life cycle of stars developed by 20th century astronomers rested on their ability to measure fundamental properties such as mass, radius, bolometric luminosity, effective temperature, and the mass function. 21st century astronomers have embarked on a similar quest to understand the evolution of brown dwarfs but have been hampered by their intrinsic faintness, the lack of a mass-luminosity relation, and the fact that most of their radiation is emitted at infrared wavelengths. While progress has been made in understanding the hotter brown dwarfs that populate the L and T spectral classes, the cooler brown dwarfs in the Y class, some of which have effective temperatures as low as ~250 K, have proven more difficult to investigate. In this proposal, we aim to measure three fundamental properties - the bolometric luminosities, effective temperatures, and the mass function - of the coolest brown dwarfs in the T and Y classes. Using the broad wavelength grasp of JWST, we will measure the bolometric luminosities of the brown dwarfs with spectral types later than T5 within 20 pc of the Sun. Since all brown dwarfs are effectively the size of Jupiter, we can then use the Stefan-Boltzmann law to measure their effective temperatures to ~25 K. The LTY luminosity function will also be compared to simulated populations of brown dwarfs that have formed and evolved over the history of the Galaxy to measure the functional form of the mass function along with its low-mass terminus.
Rocky exoplanets are abundant in the Galaxy. However, it is still unknown how often, and under what conditions, these small worlds can maintain atmospheres. Here we propose to measure thermal emission from the dayside of TRAPPIST-1c, a terrestrial exoplanet with temperature similar to that of Venus. This planet is the coolest rocky world with thermal emission that can be detected with JWST. Our observations will constrain the planet's surface pressure and the atmospheric carbon dioxide abundance, and distinguish at 4 sigma confidence between a bare rock planet and a Venus-like composition. The presence of a thick atmosphere would be a positive indication that the TRAPPIST-1 planets formed in a volatile-rich environment, motivating an aggressive observing program for the cooler, potentially habitable planets in this remarkable system.
Probing the accretion disks around long-period planetary-mass companions (PMCs; mass $< 20$ Jupiter masses with orbits $> 100$ AU) is valuable to study the origin of gas giants and their satellites at a level of detail not accessible to imaged planets at small separations. In theory, these disks are expected to be large and bright at radio wavelengths. Nonetheless, dedicated ALMA surveys at 0.88 mm and 1.3 mm have all yielded non-detections, indicating that PMC disks are distinct from those around free-floating brown dwarfs/planets. One hypothesis is that PMC disks are fainter than expected because they are very compact and optically thick, with disk radii $<0.5$ AU ($1000$ Jupiter radii). Since compact disks are brighter at mid-infrared wavelengths, JWST is advantageous to detect PMC disks and characterize their bulk properties at a population level. Here we propose a JWST MIRI imaging survey of 7 young PMCs that have comparable masses and accretion signatures. We aim to directly image PMC disks for the first time, model the spectral energy distribution of the disks between 5 and 21 micron, and definitively test the compact disk hypothesis. This imaging survey has the potential to discover additional companions, and will help design future spectroscopic programs to probe the mineralogy and structure of circumplanetary disks.
The formation of stars at low metallicities, and in particular the determination of their characteristic mass scales, is a central problem in galaxy formation and evolution, i.e., to understand the properties of the high redshift universe. However, measurements of the initial mass function (IMF) in low metallicity environments have been limited because of the distance to the regions and the corresponding difficulty in characterizing low-mass sources. Studies have been performed in the Magellanic Clouds, but here the stellar populations could not be probed to the lowest masses, i.e., below the mass where the Galactic field star IMF is found to peak (~0.25 Msun for a log-normal fit). Here we propose to study the IMF in Sh2-284, at a distance of 4.5 kpc, the lowest metallicity star-forming region in the Galaxy. With the unique sensitivity of NIRCAM on JWST together with the access to the water band filters that trace the effective temperature of low-mass objects, we will be able to accurately characterize individual stars and brown dwarfs and to discriminate between background objects and cluster members down to a mass limit of 15 Jupiter masses. This is sufficient to reach past the expected IMF peak, precisely determine its shape at the low-mass end, and measure the star to brown dwarf ratio, all achieved for the first time in a metal poor environment.
The atmospheric characterisation of multiple exoplanets in the same system can provide a window into the processes that underpinned their formation and evolution. The planetary C/O ratios are of particular interest as they encode information about where the planet formed with respect to different ice lines, but precise measurements of this using current instrumentation have proved challenging. Recent observations have revealed that the nearby late K-type star TOI-178 hosts a compact system of at least six transiting exoplanets with R < 3 Earth radii, five of which form a chain of Laplacian resonances. Alongside the fact that the large planet-to-planet density variations present in the system appear difficult to theoretically explain, its resonant chain and large atmospheric signal sizes provide a well-constrained laboratory to test the main formation theories. We propose to use JWST/NIRSpec in BOTS mode with the G39SM grating to observe single transits of TOI-178 b, d, and g, providing an atmospheric characterisation of planets that span the full range of known orbital separations from the host. Amongst other things, our mock retrievals suggest that the strong constraints that we will be able to place on the abundances of H2O, CO, CO2, and CH4 will enable a precise derivation of the C/O for each planet. The combination of these measurements will facilitate the first detailed observational study using the C/O to test whether multiple planets in the same system formed in situ or migrated to their current positions.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02321
Program Title: The first blind H-alpha narrow-band survey of star-formation at z>6
Principal Investigator: Philip Best
PI Institution: Royal Observatory Edinburgh
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We propose to use NIRCam’s narrow-band filters to observe a 65 sq. arcmin mosaic in the well-studied COSMOS-CANDELS field, to identify and study ~1000 emission-line selected galaxies across cosmic time. Our primary science driver is the detection of ~40 H-alpha emitters at redshift z>6, using difference imaging between the closely-spaced F466N and F470N filters. The H-alpha emission line is the best-calibrated star-formation indicator in the nearby Universe, and narrow-band surveys have mapped the evolution of H-alpha emitters out to the peak star-formation epoch at z~2. At higher redshift, samples of star-forming galaxies and estimates of the cosmic star-formation rate density are almost ubiquitously based on rest-frame UV observations; this single approach carries a high risk of systematic effects, both in the populations of galaxies selected and in their derived properties. Our proposal will provide the first critical test of this, producing a clean, emission-line selected sample of galaxies in to the Epoch of Reionisation, whose properties will be characterised and compared against UV-selected samples. Simultaneous imaging with the F212N and F200W filters will detect ~200 faint H-alpha emitters at cosmic noon, z~2, probing a factor 5 deeper than any previous study. Using NIRCam’s remarkable angular resolution we will measure the ionised gas structures of these galaxies (and hundreds of other line-emitters at z>1.5, including ~10 [OIII] emitters at z=8.3) at sub-kpc resolution and determine how the relationship between UV and ionised gas structures varies with host galaxy properties, in order to delineate the physical processes driving star formation at these redshifts.
Exoplanets and brown dwarfs colder than 350K are predicted to have water ice clouds in their photospheres. Of these, the best candidate for early JWST studies of hydrological cycles is the nearby, cold, free-floating brown dwarf, WISE 0855. WISE 0855 shows evidence for water clouds, and with an effective temperature of 250 K, its spectrum is similar to Jupiter’s. But, crucially, WISE 0855 is warm enough to lack the thick ammonia clouds blanketing Jupiter, giving us a clear view of its water clouds. In this proposal we seek to obtain a time-series G395M spectrum to unambiguously detect WISE 0855’s solid-state water ice feature, probe its variability, and look for spectral correlations between water vapor and water ice in a time series that could be due to evaporation and condensation. The data will provide our first opportunity to study the hydrological cycle of an extrasolar world.
Interstellar dust provides the building blocks of planets and the initial grain size distribution in the parent molecular cloud is key to understanding how planets form. Under typical diffuse ISM conditions, dust grains do not grow beyond ~0.5 micron. However, within dense molecular clouds, when shielded from the harsh interstellar radiation field, ice mantles form, allowing grain growth through coagulation.

Theoretical models predict that grain growth deforms the silicate band profiles at 9.7 and 18 micron and flattens the extinction curve between 5 and 26 micron. We propose to observe, with MIRI spectroscopy, 9 independent lines of sight through 3 very dense cores, from 5 to 40 mag of Av. Our proposed measurements, made possible by the exquisite JWST sensitivity, will be a paradigm shift in the field: the simultaneous observations of the 9.7 and 18 micron silicate absorption features at such high Av, of the 5-26 micron extinction curve, and of several ice features, coupled with state-of-the-art modelling, will allow us to resolve for the first time intrinsic degeneracies in grain size, shape and porosity. This will make it possible to set unprecedented constraints on astrochemical models with wide applications to planet and star formation. We will also deliver to the community a mini atlas of spectroscopic MIR extinction curves for the observed regions, which will be the very first publicly available for high Av sightlines.

This program complements the current JWST ERS portfolio, by helping to bridge a critical gap between star and planet formation, making it an ideal addition to the Cycle 1 observations which promise to deliver revolutionary science.
Among the main sequence stars, the sub-group comprising smaller and cooler stars than the Sun, e.g. M-dwarfs, represents the ideal environment to discover and characterize temperate terrestrial planets. With an equilibrium temperature <300K LHS 1140b is an important target to expand the knowledge on the habitability of cool small planets. The measured mass and radius of LHS 1140b are compatible with a rocky core with an envelope. The radius (1.7 Rearth) places the planet right in the middle of the Fulton gap. HST observations have set hints on the possibility of a H2-dominated envelope with the presence of H2O. However, the star has shown activity on its surface and this is likely to contaminate the planetary spectral signature especially in the optical and HST/WFC3 wavelength ranges. We propose to use NIRSpec to measure the planet’s transmission spectrum at 1.7 - 5.2 microns, and we expect the precision achieved not only will definitely disentangle the stellar activity spectral signature from the planetary spectrum, but also shed light onto the nature of LHS 1140b atmosphere.
We propose NIRSpec and MIRI spectroscopy to investigate the physical and chemical properties of a target-of-opportunity interstellar object (ISO), to help elucidate the nature and origin of this fundamentally new class of astronomical body. We will perform a deep search for outgassing using NIRSpec prism observations over three epochs. If a coma is clearly visible, higher-resolution grating observations will be used to measure the production rates of multiple coma gases (including H2O, CO2, CH4, CH3OH, CO, HCN, H2CO and C2H6), to determine the ice content of the nucleus. MIRI-LRS spectroscopy will reveal the coma dust composition. In the absence of significant outgassing, our near-to-mid-IR observations have been designed to directly measure the surface composition and spectral shape, for comparison with Solar System asteroids. We will target an ISO similar to (or brighter than) 1I/Oumuamua and 2I/Borisov, with $V \sim 11.24$ mag. Only JWST has the sensitivity to perform the required gas, dust and nucleus measurements in the event of a faint apparition. The proposed observations will provide new insights into the diversity of protoplanetary disk midplane chemistry in our Galaxy, and in a sufficiently bright object ($V<19$), will provide a comprehensive inventory of the volatiles available for pre-biotic chemistry in a planetary system other than our own.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02344
Program Title: Mapping emission and absorption line metallicities onto the same univeral scale
Principal Investigator: Patricia Schady
PI Institution: University of Bath
Collaborators: Nial Tanvir University of Leicester, Valerio D’Elia INAF, Osservatorio Astronomico di Roma, Kasper Heintz University of Iceland, Andrew Fruchter Space Telescope Science Institute, Johan Fynbo University of Copenhagen, Niels Bohr Institute, Benjamin Gompertz The University of Warwick, John Graham Peking University, Jochen Greiner Max-Planck-Institut fur extraterrestrische Physik, Dieter Hartmann Clemson University, Pall Jakobsson University of Iceland, Jure Japelj Universiteit van Amsterdam, Tanmoy Laskar University of Bath, Andrew Levan Radboud Universiteit Nijmegen, Carole Mundell Liverpool John Moores University, Daniel Perley Liverpool John Moores University, Silvia Piranomonte INAF, Osservatorio Astronomico di Roma, Giovanna Pugliese Universiteit van Amsterdam, Ruben Salvaterra INAF, Instituto di Astrofisica Spaziale e Fisica, Milano, Sandra Savaglio University of Calabria, Boris Sbarufatti The Pennsylvania State University, Rhaana Starling University of Leicester, Gianpiero Tagliaferri INAF, Osservatorio Astronomico di Brera, Merate, Christina Thoene Instituto de Astrofísica de Andalucía (IAA), Susanna Vergani Observatoire de Paris - Section de Meudon, Darach Watson University of Copenhagen, Niels Bohr Institute, Philip Wiseman University of Southampton, Annalisa De Ga Observatoire de Geneve, Tanita Ramburuth-Hurt University of Geneva-Department of Astronomy, Christina Konstantopoulou Observatoire de Geneve, Bo Milvang-Jensen University of Copenhagen, Niels Bohr Institute, Andrea Rossi INAF, Osservatorio di Astrofisica e Scienza dello Spazio, William Bowdery University of Bath, Robert Yates University of Surrey, Hsiao-Wen Chen University of Chicago, Klaas Wiersma The University of Warwick, Daniele Malasani Technical University of Denmark-DTU Space, Maryam Arbabzadeh University of Western Australia, Eliana Palazzi INAF, Osservatorio di Astrofisica e Scienza dello Spazio, Lise Christensen University of Copenhagen, Niels Bohr Institute, Antonio de Ugarte Postigo Instituto de Astrofisica de Andalucía (IAA), Ruben Garcia-Benito Instituto de Astrofísica de Andalucía (IAA), Massimiliano De Pasquale Istanbul University Science Faculty, Department of Astronomy, C. Kouveliotou George Washington University, Elizabeth Stanway The University of Warwick, Bethan Easeman University of Bath

The metallicity of galaxies across cosmic epoch is a pillar of galaxy evolution models. JWST aims to revolutionise metallicity determinations of distant and fainter populations of galaxies that have been out of reach with current technology, to trace the history of cosmic chemical enrichment and its relation to star formation. However, metallicity estimates based on emission line spectroscopy generally rely on line indices that are calibrated at lower redshifts, and often have significant scatter or are multi-valued. Another route to abundance determinations at z>2 is via absorption spectroscopy of gamma-ray burst afterglows. Thanks to their brightness, in some cases this has allowed highly detailed studies of the cold gas phase of the GRB hosts along the line of sight to the burst. Although some of this gas must lie close to the burst, absorption tends to be dominated by gas at tens or hundreds of pc from the burst location. These systems therefore provide an excellent characterisation of the host abundances.

We propose a JWST/NIRSpec spectroscopic study of a sample of 10 GRB host galaxies at 2.0<z<4.7 where such absorption-based, detailed abundance analyses have already been conducted, thus enabling the first cross-calibration of absorption and emission line metallicities within the same star-forming galaxies. GRBs occur preferentially in low to moderate metallicity hosts and likely represent prototypical high-redshift star-forming galaxies. Our proposed program will thus provide a foundational mapping between accurate absorption abundance results and common emission line diagnostics that will be of wide value across the JWST program portfolio.
Observations of quiescent galaxies at redshifts z~2 have yielded many surprises, often upending contemporary models. JWST will undoubtedly provide further unexpected discoveries regarding the properties and progenitors of this key galaxy population. However, it will remain a challenge to study their internal structures and resolved stellar populations. We propose NIRSpec IFU observations of a strongly lensed massive quiescent galaxy that is, by far, the brightest high-redshift example. Studying this unique object will enable us to dissect a z=1.95 massive galaxy, seen ~1 Gyr after quenching, at a level of detail unprecedented beyond the local universe and impractical for any other known z~2 source. We will (1) spatially resolve detailed star formation histories and stellar chemical abundances of the bulge and inner and outer disk, revealing key formation events to test proposed connections between a central gas-rich starburst and galaxy-wide quenching; (2) produce the first 2D stellar kinematic map of any high-z galaxy, enabling us to assess whether the quenching process was linked to kinematic transformations; (3) produce the first 2D map of neutral gas in a high-z quiescent galaxy via ISM absorption and determine whether this gas sustains low-level star formation; and (4) probe the possible origins of the initial mass function (IMF) variations claimed in local early-type galaxies by comparing the IMFs of stars born in the bulge and disk. These detailed insights into the spatially resolved formation history of a massive quiescent galaxy are only possible for this unique target combined with the resolution, sensitivity, and wavelength coverage of JWST.
The CoRoT, Kepler and K2 missions have revealed a new class of planet, so-called lava planets, which have bulk densities consistent with terrestrial composition, but dayside temperatures hot enough to melt—and vaporize—rock. Of these planets, the most promising candidate for atmospheric and surface characterization is K2-141b: it has a density of 8 g/cm^3, a dayside temperature measured by Spitzer to be 2125 K, and an orbital period of 6.7 hrs around a J=9 star. We propose to monitor K2-141b for three complete orbits of the planet with MIRI LRS for just under 21 hrs of time. These observations will allow us to measure the vertical atmospheric structure on the dayside of the planet via the 9 micron SiO feature, to determine the presence of an extended atmosphere via the planet’s nightside temperature, and to search for rock clouds that might form as the supersonic winds blowing towards the nightside cool and condense. JWST is uniquely suited to detect SiO in emission spectra of lava planets and MIRI LRS is the only instrument able to probe low nightside planetary temperatures to place stringent constraints on the presence of a global atmosphere. The combination of the strong signal expected from K2-141b and the large contrast at long wavelengths, makes MIRI LRS observations of K2-141b the approach for testing theories of cloud formation in a fully condensable atmosphere, and testing atmospheric loss on the extreme scenario of a planet skimming its star’s corona.
Supernova (SN) 2014C is a rare massive stellar death, in which a hydrogen-poor progenitor star explodes and interacts with its lost hydrogen-rich envelope. This is unlike most other stripped-envelope (SE) SNe that explode long after the envelope is stripped, and never show signs of interactions. The mass loss process that creates SESNe is not well understood, and SN 2014C presents us with an unprecedented opportunity to probe the history of mass loss of a SESN progenitor by observing the still ongoing interaction. Previous IR observations have revealed a tentative sign of silicate dust in the CSM, unlike other interacting SNe. We propose to obtain near- to mid-infrared spectroscopy of SN 2014C with NIRSpec IFU and MIRI MRS. These observations will probe emission features of different dust species, allowing us to confirm the presence of silicate dust and to robustly measure the dust composition in the CSM. They will also allow us to detect other molecular species, probing the gas chemistry of the CSM and other properties. We will compare the IR spectroscopic signatures of the CSM of SN 2014C to that around well-observed massive stars in the Milky Way and the Magellanic Clouds, to constrain what type of stars are able to produce SESNe. These observations are timely as the SN will inevitably fade away.
The survival of widely separated binary stars within dense, low-mass dwarf galaxies depends strongly on the nature of dark matter. The standard Cold Dark Matter (CDM) model generically predicts that "ultrafaint" dwarf galaxy dark matter halos are composed of a smooth component with a centrally-divergent density "cusp", plus multitudes of self-bound subhalos, sub-subhalos, etc., down to a mass limit set by particle physics. Both smooth and clumpy components disrupt wide binary stars, via tidal forces and perturbative encounters, respectively, leaving an imprint on the binary separation function.

We propose to exploit JWST's unprecedented sensitivity to perform a search for wide binary stars (separation > 1000 A.U.) in the nearby ultrafaint dwarf galaxy Draco II, which offers favorable conditions for a search and will be observed as part of Early Release Science program 1334. We will apply Bayesian techniques to detect binary stars as closely separated pairs, and to infer the binary separation function directly from the distribution of stellar positions. We will interpret the results in the context of wide binary formation and survival in a dense dark matter halo environment, thereby providing novel tests of star formation in extreme environments and--especially if wide binaries are detected--a potentially definitive test of the CDM paradigm.
NIRSpec MOS is a multiplexing workhorse that can provide high-resolution spectroscopy for hundreds of distant galaxies in a single exposure. Its extreme sensitivity and novel wavelength coverage will provide a completely unprecedented window into the star formation histories and elemental abundances of galaxies in the early universe. However, there is a critical challenge: the micro-shutters are substantially smaller than many targets of interest, meaning that median galaxy at $1 < z < 3$ will have 65% of its light blocked by the shutter. More dangerous perhaps is that due to the intrinsic coupling between stellar populations and galaxy morphology, the light that is measured will unavoidably provide a biased view of a galaxy’s stellar populations. Here we propose to solve this problem by developing a tool to build loose, flexible, spatially resolved models of the stellar populations in each galaxy. The model will knit together both resolved and unresolved imaging and aperture spectroscopy into a single unified framework by applying the spectrum as an integral constraint over the area of the MOS shutter. The model will be trained on realistic images and spectra from hydrodynamic simulations. The extent to which the shutter spectrum can be generalized to the entire galaxy will be guided by the resolved photometric colors. We will rapidly develop and release this open-source tool to the community in combination with a live demonstration on relevant ERS data in order to maximize the scientific potential of the NIRSpec MOS. Investing early in analysis software developed by the community is an efficient way to ensure the $10$ billion JWST provides the best scientific returns.
Proposed Category: GO  
Scientific Category: Exoplanets and Exoplanet Formation  
ID: 02358  
Program Title: Under the Light of a Dead Star: Revealing the Atmospheric Composition of a White Dwarf Planet  
Principal Investigator: Ryan MacDonald  
PI Institution: Cornell University

Around 50 worlds beyond our solar system have undergone atmospheric characterization in the last 20 years. Despite the incredible diversity of exoplanets studied to date, all these worlds share one common aspect: their planets orbit main sequence stars. Until recently, the question of the conditions in planetary atmospheres following the death of their star has been the sole purview of theoretical speculation.

Recently, Vanderburg et al. (2020) reported the first transiting planet orbiting a white dwarf: WD 1856b. This planet provides our first opportunity to study the atmospheres of post-main sequence planets.

We propose to conduct the first atmospheric reconnaissance of WD 1856b. The short transit duration of WD 1856b (8 minutes) allows us to rapidly construct an exquisitely high-quality transmission spectrum in a fraction of the typical time required to study transiting exoplanets. With just four transits (8 science hours) with the NIRSpec Prism, we will achieve the first precision characterization of a post-main sequence planet and the first exploration of a cool giant exoplanet (~160 K) of similar temperature to Jupiter. Despite the short time allocation of our program, we expect to achieve some remarkable firsts in exoplanet science: the first detections of CH4, NH3, and PH3 in a transiting exoplanet atmosphere, and hence knowledge of the C/H, N/H, P/H, and O/H ratios of an exoplanet atmosphere for the first time. Our program will also allow a lower bound to be placed on WD 1856b's mass, constraining its migration history. The atmospheric constraints provided by this program will offer the first glimpse into the future of planetary systems like our solar system.
Spectroscopic and polarimetric studies of a subset of the L-type asteroids has indicated that these objects may contain ~30% calcium-aluminum inclusions (CAIs), the first solids to condense out of the disk during the Solar System’s formation. This is a surprising result because even the most CAI-abundant meteorites contain only 3-5% of these inclusions. High CAI content is considered to be indicator of ancient origin, and the confirmation of the CAI abundance in these asteroids would make them plausibly the most ancient objects in the Solar System. In addition, their existence has important implications for the timing of events in the Solar System’s early history and the origins of the Solar System’s raw materials. The spinel that is a major constituent of CAIs has prominent spectral signatures in the mid-IR, and mid-IR spectroscopy would readily detect this material and robustly differentiate high-CAI bodies from other candidate asteroid compositions. We propose to observe a set of L-type asteroids with high apparent CAI content in order to confirm or refute the high-CAI hypothesis, and to constrain the disk formation region and thermal/aqueous alteration histories of these unusual objects.
Over the last twenty years increasingly deeper and wider near-infrared photometric surveys have identified evolved massive galaxies at continually higher redshifts. These rapidly-forming and quenching galaxies create significant tension with cosmological models of galaxy formation and highly constrain the implementation of AGN feedback physics. Using UltraVISTA/COSMOS, the deepest and widest-field near-IR survey to date we have identified three galaxies with Log(M/M_sun) > 11.5 at z ~ 5 with robust photometric redshifts. We propose deep medium-resolution NIRSpec spectroscopy in G235M/F170LP and G395M/F290LP, to target multiple prominent rest-frame optical absorption/emission lines, as well as NIRCam F444W and F200W imaging to determine morphologies. These data will be used to: 1) Confirm the redshifts and stellar masses of these extreme objects during the epoch when they form most of their stellar mass, 2) measure the star-formation rates, star-formation histories and mass distributions of these galaxies to constrain their assembly history, and 3) determine the source of ionization radiation and determine if they contain prominent AGN. The long-wavelength capability of JWST means this will be the first rest-frame optical study of massive galaxies during their peak formation epoch and will return key information on how such galaxies form so fast, so early. One of our candidates has an SED consistent with being a fully quenched and passive galaxy at z ~ 5. If confirmed, this will be by far the highest-redshift passive galaxy to date, and will have significant implications for AGN quenching models.
A central problem in astrophysics regards the formation of massive galaxies, which models suggest may be driven by powerful, compact starbursts with energetic feedback. Most massive galaxies form at high redshift (z > 3), but astronomers have recently discovered an exceptional low redshift (z~0.5) population of massive compact starbursts with powerful ionized and molecular outflows (velocities up to 3000 km/s and radii up to 50 kpc) that provide a unique testbed to observe this process in detail. A wide range of optical, mid-IR, molecular, and radio observations of these galaxies have illustrated their morphologies and the energetics of their outflows, but critical open questions remain that can only be answered with sensitive mid-IR spectroscopy with JWST: Is the powerful feedback driven by star formation or a hidden AGN? What are the precise rates of dust-obscured star formation? And do the galaxies drive outflows even in highly ionized gas? This proposal seeks MIRI medium-resolution spectroscopy of five representative compact starbursts to answer these questions, in order to definitively understand their formation processes and those of typical massive galaxies in the early Universe.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02372
Program Title: Deep Characterization of the Atmosphere of a Temperate Sub-Neptune
Principal Investigator: Renyu Hu
PI Institution: Jet Propulsion Laboratory
Co-Investigators
Mario Damiano Jet Propulsion Laboratory

Characterizing the atmospheres of small and temperate exoplanets observationally will make a great stride forward in determining their potential habitability. With an equilibrium temperature <300 K, the sub-Neptune K2-18 b has spectral features detected at 1.1 - 1.7 microns in transmission, and thus an H2/He-dominated atmosphere amenable for further characterization via transmission spectroscopy. This planet presents a uniquely low-risk path for detailed studies of its atmospheric composition, photochemistry, and potential habitability. We propose to use NIRSpec to measure the planet's transmission spectrum in 1.7 - 5.2 microns at a resolution of R=100. The transmission spectrum will be sensitive and precise enough to measure the abundances of H2O, CH4, NH3, CO2, and CO, constrain the cloud pressure, and detect photochemical products such as HCN and N2O in the atmosphere of K2-18 b. The combination of these gases would determine whether the planet is a mini-Neptune with a massive H2 atmosphere or an ocean planet with a thinner atmosphere. Our program will thus usher in an era of deep characterization of temperate and volatile-rich exoplanets.
The NIR-MIR SED of galaxies is dominated by spectral features from polycyclic aromatic hydrocarbon (PAH) molecules fluorescing in regions illuminated by FUV photons. In low metallicity systems (Z < 0.2 Zô), previous studies with Spitzer have revealed a substantial deficiency in the emission and abundance of PAHs, the origin of which remains unexplained due to the lack of deep, resolved, multi-band photometry or spectroscopy. We propose to obtain NIRCam and MIRI imaging to observe the 3.3, 7.7, and 11.3 micron PAH features in dusty star-forming regions in two low metallicity galaxies, IC 1613 (15% solar) and Sextans A (8% solar). The observations will allow us to 1) estimate the PAH properties, particularly their abundance, ionized fraction, and size distribution; and 2) correlate those properties with other tracers of the ISM, such as the star formation rate density, the distance and UV spectrum of massive stars, the distance to PAH-producing stellar sources, the ISM column density of gas and dust, and gas-phase abundances. By observing how the PAH properties and abundance vary with environment, we will constrain the mechanisms responsible for the formation, destruction, excitation, and low abundance of PAHs in those poorly shielded low metallicity environments. Since JWST will measure star formation rates as low as 10 Mô/yr from PAH emission at the peak of cosmic star formation at redshift z~2 when the average metallicity of the universe was about 10% solar, it is crucial that we deepen our physical understanding of PAHs at low metallicity. This proposal includes a joint HST 3 orbit request to map the dust extinction required to normalize the PAH abundance in IC 1613.
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02395
Program Title: A comprehensive view of a binary neutron star merger
Principal Investigator: Andrew Levan
PI Institution: Radboud Universiteit Nijmegen
Co-investigators
Stephen Smartt The Queen's University of Belfast, Andrew Fruchter Space Telescope Science Institute, Alexander Van der Horst George Washington University, Anders Jerkstrand Stockholm University, Ashley Chrimis Radboud Universiteit Nijmegen, Benjamin Gompertz The University of Warwick, Bo Milvang-Jensen Cosmic Dawn Center, Niels Bohr Institute, Chris ashall Florida State University, Daniele Malesani Technical University of Denmark-DTU Space, Eliana Palazzi INAF, Osservatorio di Astrofisica e Scienza dello Spazio, Filippo D’Ammando INAF Istituto di Radioastronomia, Giorgos Leloudas Technical University of Denmark-DTU Space, Hanindyo Kuncarayakti University of Turku, Ilya Mandel Monash University, Ting-Wan Chen Stockholm University, Jens Hjorth University of Copenhagen, Niels Bohr Institute, Joseph Lyman The University of Warwick, Kasper Heintz University of Iceland, Kate Maguire University of Dublin, Trinity College, Klaas Wiersema The University of Warwick, Komkom Bhommbhakdi Space Telescope Science Institute, Lluis Galbany University de Granada, Luca Izzo University of Copenhagen, Niels Bohr Institute, Lukasz Wyrzykowski Warsaw University, Maria Grazia Bernardini INAF, Osservatorio Astronomico di Brera, Merate, Marica Branchesi Gran Sasso Science Institute, Matt Nicholl University of Birmingham, Michal Michalowski Astronomical Observatory, Adam Mickiewicz University, Nadeen Sabha Universitat Innsbruck, Institut fur Astronomie, Paolo D’Avanzo INAF, Osservatorio Astronomico di Brera, Merate, Patricia Schady University of Bath, Paul O’Brien University of Leicester, Peter Jonker Space Research Organization Netherlands, Ruben Salvaterra INAF, Instituto di Astrofisica Spaziale e Fisica, Milano, Rubina Kotak The Queen's University of Belfast, Samantha Oates University of Birmingham, Seppo Mattila University of Turku, Sheng Yang Osservatorio Astronomico di Padova, Stefano Benetti Osservatorio Astronomico di Padova, Steve Schulze Weizmann Institute of Science, Susanna Vergani Observatoire de Paris - Section de Meudon, Sylvain Chaty Commissariat a l’Energie Atomique (CEA), Zhaping Jin Chinese Academy of Sciences, James Gillanders The Queen’s University of Belfast, Quentin Poona Carrollton University, Youdong Hu Instituto de Astrofisica de Andalucia (IAA)

We propose a comprehensive public program targeting the electromagnetic counterpart to a gravitational wave source. The counterpart - a kilonova - is created by rapid neutron capture (the r-process) in the neutron-rich ejecta from the merger of two neutron stars, or a neutron star and a black hole. The one kilonova studied in detail to date confirms predictions that they are faint, red and fast-evolving. The unique combination of depth and wavelength coverage from JWST will enable the next pivotal breakthroughs in their study. We will map the bolometric luminosity to determine the quantity of heavy elements produced. Their synthesis sites will be isolated by mapping the relative strengths of blue emission (from lighter elements) and red emission (from heavy elements). Late time photometry can detect the presence of any long-lived radioisotopes from the heaviest elements. Our spectroscopic observations will go further, enabling us to decompose the various kilonova components, and search for individual elements either in the early or late phases of the KN. Finally, the deep observations will provide a unique route to determining the distance to the host galaxy, enhancing the accuracy of the gravitational wave derived Hubble constant, and will provide a high-resolution view of the merger environments. Together these observations will create significant new knowledge about the origin of the heaviest elements known in nature, including those of great value (e.g. gold) and some which are vital to life on Earth (e.g. iodine, thorium). To enhance community value, we propose a public programme and will make reduced products available shortly after the observations.
We propose to observe the full 5-28 micron spectrum of the giant HII region in NGC 5253. The dominant infrared cluster in this galaxy is among the most luminous star-forming regions in the local universe. Consistent with a $10^9$ L$_{\odot}$ IR luminosity, low resolution spectra from ISO and Spitzer reveal high excitation from intense and hard radiation fields within the HII region. But these large aperture IR observations could not isolate the HII region core from other nearby clusters. JWST can see through the more than 15 magnitudes of visual extinction to resolve the 3-pc radius IR nebula from more extended nebulosity. Thus the mid-IR spectrum of the giant HII region surrounding the forming super star cluster (SSC) can be separated from lower excitation gas associated with older clusters. The final spectrum will provide a valuable template for the spectrum of a forming SSC for applications at higher redshifts. The line strengths computed from these spectra will be combined with optical and submillimeter data, and analyzed with grids of models of varying radiation field intensity and hardness and with different distributions of gas and dust.
Proposal Category: AR
Scientific Category: Galaxies
ID: 02410
Program Title: How efficiently do galaxies produce ionizing photons in the epoch of reionization?
Principal Investigator: Ramesh Mainali
PI Institution: NASA Goddard Space Flight Center
CoInvestigators
Jane Rigby NASA Goddard Space Flight Center

Determining the role of galaxies in reionizing the Universe is a fundamental goal in galaxy evolution and cosmology. One of the key variables in reionization models is the ionizing photon production efficiency, which currently remain largely unconstrained at the epoch of reionization. Leveraging datasets from two archival ERS programs (program 1324 and 1345), we propose to investigate the ionizing photon production efficiency of both bright and faint galaxy populations in the epoch of reionization. We will directly constrain ionizing photon production efficiency via measurement of extinction corrected H-alpha luminosity and rest-frame UV continuum luminosity. This will provide, for the first time, the direct constraint on ionizing photon production efficiency at z>6, informing the ionizing photon budgets of galaxies in the reionization epoch. Additionally, we will measure how ionizing photon production efficiency evolves over cosmic time, and how it varies with galaxy properties. Together, these results will serve as crucial inputs in theoretical models mapping the timeline and topology of reionization.
Centaurs are small bodies orbiting between the orbits of Jupiter and Neptune. These objects are transitioning from orbits in the Scattered Disk beyond Neptune to those of Jupiter Family Comets that enter the terrestrial planet region. Cometary activity has been observed in some of Centaurs, indicating the presence of volatiles. While studies of the dust coma surrounding active Centaurs have been performed, direct observations of the volatiles responsible for the activity are much more sparse. CO has been detected in a few active Centaurs, while CO2 has not been detected (mostly due to difficulties observing CO2 from ground-based facilities) and H2O has only been detected in one Centaur (29P). An inventory of H2O, CO2, and CO in active Centaurs is vital to understanding their composition and activity. We propose to use JWST NIRSpec to obtain observations of H2O, CO2, and CO in a sample of active Centaurs. We will also perform sensitive searches for water ice absorption in the coma. JWST NIRSpec is uniquely suited for this study because a) it has unsurpassed sensitivity at IR wavelengths, allowing for orders of magnitude better sensitivity than previous searches for these molecules, and b) JWST’s space-borne nature allows it to observe the fundamental bands of H2O and CO2, which cannot be observed from the ground due to severe telluric absorption.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02417
Program Title: Physical Characterization of a Massive Galaxy Protocluster ~1 Billion Years after the Big Bang
Principal Investigator: Dominik Riechers
PI Institution: Cornell University

Hyper-luminous dusty massive starburst galaxies in the first billion years of cosmic history trace some of the highest density peaks in the early universe, making them ideal benchmarks for the growth of large-scale structure. We here propose a comprehensive JWST study of the richest galaxy protocluster known at these epochs (with at least 30 members within 5 comoving Mpc, including 2 with extended Lyman-alpha halos), which is associated with one of the only three known unlensed massive starbursts at z>5. Six-band rest-frame optical to near-infrared photometry and resolved spectroscopy of H-alpha, H-beta, [NII], [SII], and [OIII] will reveal the morphology and ages of the unobscured starlight from young and old populations, the star formation histories and energetic processes in and metal enrichment of the interstellar medium and its kinematic structure, and potential feedback processes due to intense star formation or buried active galactic nuclei down to sub-kpc scales in "typical" galaxies and dusty starbursts alike - with a secure handle on dust extinction for the entire sample. This will provide a reference sample for studies of "blank field" selected samples at similar epochs from the GTO programs (which entirely miss exceptionally rare regions like the one studied here), allowing us to study the environmental dependence of galaxy evolution and the resulting galaxy properties as a function of local galaxy density. Requiring only 4.7hr on source, this program thus will make a key addition to the portfolio of JWST in its quest to solve the final mysteries of galaxy evolution towards the earliest epochs.
This is a proposal for 98 hours of NIRSPEC/PRISM observations of 59 trans-Neptunian objects and Centaurs (hereafter, TNOs). Our targets cover a diverse range of orbital characteristics, sizes, albedos, and surface compositions complementary to the GTO targets. The TNO population includes some of the most primitive bodies in the Solar System and preserves a record of the significant dynamical dispersal of the protoplanetal following the era of planet formation.

Spectroscopy of TNOs is a powerful tool to study their surface composition but has reached its limits from ground-based facilities and there is no instrumentation available, or planned for the next 10 years, capable of significantly increasing that existing sample with sufficient quality for compositional analysis.

NIRSpec will be able to provide high-quality data, even in its low resolving power mode, that will surpass the quality of the data available by orders of magnitude. The goal of this proposal is to assess the relative ratio of water ice, complex organics, silicates, and volatiles on the surface of a large sample of TNOs. This information is vital to improving models of the formation of our Solar System and other planetary systems and relates to disciplines such as astrochemistry, cosmochemistry, and astrobiology, being relevant to our understanding of the origin of water and life on Earth and possibly elsewhere.

This is the time to provide such critical information to the scientific community and JWST is the optimal avant-garde tool to face that challenge.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02420
Program Title: Probing the Terrestrial Planet TRAPPIST-1c for the Presence of an Atmosphere
Principal Investigator: Alexander Rathcke
PI Institution: Technical University of Denmark-DTU Space

Lars Buchhave Technical University of Denmark-DTU Space, Nestor Espinoza Space Telescope Science Institute, Mercedes Lopez-Morales Smithsonian Institution Astrophysical Observatory, Neale Gibson University of Dublin, Trinity College, Jens Hoeijmakers Lund University, Joao Mendonca Technical University of Denmark, Aaron Bello-Arufe Technical University of Denmark-DTU Space, Andrea Guzman Mesa University of Bern, Daniel Kitzmann University of Bern, Chloe Fisher University of Bern, Kevin Heng University of Bern, Adam Burgasser University of California - San Diego, Thea Kozakis Technical University of Denmark-DTU Space, Hannah Diamond-Lowe Technical University of Denmark-DTU Space, Brett Morris University of Bern, Matthew Hooton University of Bern

Since the discovery of the first exoplanets, a prime aspiration has been characterization of planets akin to our own Earth. JWST will, for the first time, enable observations of the atmospheres of terrestrial planets, allowing us to understand the nature and diversity and ultimately the habitability of Earth-like worlds. Facilitated by the broad spectral coverage of the NIRSpec Prism, we propose to characterize the atmosphere of the terrestrial-sized exoplanet TRAPPIST-1c, which is one of the most favorable such targets due to its significant transit depth and proximity to Earth. The seven terrestrial planets in the TRAPPIST-1 system receive between 0.1 to 4 times the irradiation of Earth and thus form a unique natural laboratory for testing and understanding planetary environments, their composition and their habitability. Planets b, d, e, and f are part of GTO programs and observations of planet c will thus allow comparative atmospheric characterization of all the inner planets in the TRAPPIST-1 system. Our program will enable the detection of the most probable types of clear atmospheres for TRAPPIST-1c, and its atmospheric constituents. Distinguishing between a cloudy/hazy atmosphere and no atmosphere is extremely challenging for any terrestrial planet, including planet c, and will require occupying JWST for close to 100 hours. We submit that the most fruitful use of JWST will be to reveal the clear-atmosphere Earth-like planets early, using short visits like this proposal, enabling ground-breaking exhaustive characterization of the most favorable Earth-like planets with clear atmospheres before the end of JWST's lifetime.
The ionizing spectral energy distributions (SEDs) of young stellar populations are a key ingredient in studies of galactic star formation histories, feedback, and nebular emission. While observations indicate that galaxies’ ionizing spectra become significantly harder at low metallicity, current stellar population models struggle to reproduce the observed high-ionization emission lines. Observationally, constraining the ionizing spectral shape with UV and optical emission lines is difficult, given uncertainties due to dust extinction, underlying stellar spectral features, relative abundances, and radiative transfer effects.

Here, we propose MIRI MRS spectroscopy to measure a suite of nebular emission lines with ionization potentials of 22-97 eV and constrain the ionizing spectral shape of six low-metallicity galaxies. The sample galaxies have existing HST UV spectra to constrain the non-ionizing spectrum and span a range of metallicities and ionization conditions. By comparing the MIR spectra with photoionization models, we will systematically test ionizing SED models and different proposed sources of hard ionizing photons. Our results will serve as new observational constraints that will be used to improve low-metallicity SED models. In addition, with spatially resolved maps of [Ne III], [SIV], and [S III] lines, we will compare the ionization structure of different star-forming knots and trace the propagation and escape of ionizing radiation. These MIRI observations will provide new insights into stellar populations, stellar evolution, and ionizing spectra at low metallicity.
We propose a targeted 18.1-hour NIRSpec fixed slit prism program to spectroscopically confirm 11 of the brightest known z=9-10 galaxy candidates. This sample capitalizes on the uncorrelated nature of pure parallel observations to overcome cosmic variance and leverages a full multi-wavelength selection process to minimize contamination without sacrificing completeness. The abundance of bright galaxies at z>8 can provide key constraints on models, as the predicted abundance varies greatly when different physical prescriptions for gas cooling and star formation are implemented. These galaxies likely also reside in overdensities, potentially representing some of the earliest sites of cosmic reionization. However, these candidate galaxies require spectroscopic confirmation to prove their validity, and pave the way for deeper Cycle 2 exploration. Our observations will provide clear redshift confirmation via detection of the Lyman break, as well as measurements of the O32 line ratio, enabling the characterization of the ionizing power of these galaxies early in the epoch of reionization.
Most nearby spiral galaxies show thick disks of interstellar gases supported and fed by the feedback from star formation. This material serves as the interface between the disk and the circumgalactic medium; it regulates the flows between the two, dictating the time and length scales for the circulation of baryons and metals within a galaxy. Interstellar thick disks are complex, showing the full range of phases as the underlying thin disks; this includes a cold neutral/molecular medium from which thick disk stars are actively formed. We propose to take advantage of the incredible leaps in resolution and sensitivity offered by JWST to map the PAH emission from the interstellar thick disk of the canonical edge-on spiral galaxy NGC 891, the the local galaxy with the best-studied thick disk over all phases. Our proposed images probe the interstellar thick disk to unprecedented heights, probing the distribution of metal-bearing PAHs to the boundary between the galaxy and its circumgalactic medium. With our proposed images we will 1) characterize the spatial distribution of PAH emission, including decomposing the emission associated with the well-known diffuse ionized gas from the other phases; 2) identify thick disk filaments fed directly by disk star forming regions to determine the stellar energy required to create outflows from the disk; and 3) obtain a complete census of star formation and masses of young stellar clusters in the thick disk. Together these goals will help paint a complete picture of the physics at work in shaping and maintaining the physical and phase structure of the thick disk interstellar medium.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02437
Program Title: Diamonds are Forever: Probing the Carbon Budget and Formation History of the Ultra-Puffy hot Jupiter WASP-127b
Principal Investigator: Stefan Pelletier
PI Institution: Universite de Montreal
CoInvestigators
Bjorn Benneke Universite de Montreal, Romain Allart Universite de Montreal

Hot Jupiters present an unprecedented opportunity to answer long-standing question regarding the formation processes of giant planets by measuring the carbon-to-oxygen ratio of their atmospheres. Precisely measuring a planet’s C/O ratio however, requires simultaneously measuring the abundance of all major carbon- and oxygen-bearing species present in its atmosphere, which remains an extremely challenging task with currently available instrumentation. WASP-127b currently harbours both the strongest known water and carbon absorption features of any exoplanet to date as measured from HST and Spitzer. Unfortunately, those observations cannot distinguish between a CO2-rich low C/O case, or a CO-rich high C/O case. Both of these scenarios would have drastically different implications not only regarding WASP-127b’s atmospheric chemistry, but also in terms of what mechanisms are at play during giant planet formation. We propose to observe a single transit of the ultra-puffy hot Jupiter WASP-127b using NIRSpec BTS to determine what is the dominant carbon species of its atmosphere. Especially when combined with already scheduled GTO NIRISS SOSS transit observations that will exquisitely constrain the H2O abundance, the inferred precise C/O ratio will likely be able to pinpoint not only where in the protoplanetary disk WASP-127b formed, but also whether the metallic content of its envelope came from enriched gas due to pebble drift or rather from planetesimal accretion. Distinguishing between these scenarios will provide invaluable information regarding the formation process not only of the intriguing population of hot Jupiters, but also giant planets in general.
The centers of galaxy clusters represent an ideal laboratory to study black hole feeding and feedback. In nearly every cluster that has been observed, cooling of the intracluster medium (ICM) appears to be well-regulated by a mechanically-efficient, radio-loud AGN within the central giant elliptical galaxy. This mechanical power appears to offset cooling of the ICM over long (~10 Gyr) timescales, allowing only ~1% of the hot ICM to cool to low enough temperatures to form stars and fuel the AGN. This precise balance prevents the overcooling of the ICM, keeps central cluster galaxies red and dead, and keeps central AGN in a low (mechanically-efficient) accretion state. The Phoenix cluster (z=0.597) represents an exception to this paradigm, with a starburst (~800 Msun/yr) central galaxy and a rapidly-accreting central quasar. This system appears to be fulfilling many of the early “cooling flow” predictions, with evidence from X-ray spectroscopy that the hot (>10^7K) gas in the core is cooling at nearly the maximal rate. We propose MIRI IFU spectroscopy to image the core of this unique cluster. In particular, we will utilize the NeVI emission line, which probes gas at 300,000K, to map out the intermediate temperature gas both spatially and kinematically, and determine whether a cooling flow is indeed fueling the observed starburst. The full mid-IR spectrum will allow new insights into the cooling flow, ICM turbulence, the central QSO, and the cold gas reservoir.
Silicate grains comprise ~70% of Galactic interstellar dust by mass. In the diffuse interstellar medium (ISM), amorphous olivine grains produce broad spectral features at 9.7 and 18 microns, while in circumstellar environments, narrower spectral features at >9 microns reveal grain crystallinity. The absence of ISM grain crystallinity supports dust evolution models in which processing mechanisms rapidly amorphize grains. Higher (5-15%) interstellar silicate crystallinity has been observed in galaxies with very high star formation rates, where it is attributed to newly formed grains. Thus, the discovery of a visually-normal, late-type, face-on spiral galaxy at z=0.9 with significant (>95%) silicate crystallinity challenges established models. This detection was based on Spitzer IRS spectra showing structure in the galaxy’s 10 micron silicate absorption feature along lensed sightlines to the PKS 1830-211 blazar. Given that the absorber sightline also exhibits a large diversity of molecules, grain processing mechanisms may differ in this galaxy region. In order to investigate whether the IR spectral structure results from extremely high silicate crystallinity, or whether the structure is an artifact due to scattered light contamination of the IRS spectrum, we propose to observe the sightlines with MIRI-MRS to robustly establish the silicate crystallinity, and to investigate the silicate grain chemistry. If confirmed, this system may reveal variations in dust grain processing at higher redshift and/or in grains located in dense molecular clouds, which may be more prevalent in high redshift star forming galaxies, impacting dust corrections in those systems.
AGN have become key components of most galaxy evolution models, yet several open issues remain in our understanding of how the link between galaxies and their SMBHs is established and maintained. We propose to survey the host demographics of AGN during the first quarter of cosmic time in order to understand when and how the AGN-galaxy connection is established. Our study will use data from the CEERS ERS program, whose NIRCam, MIRI and NIRSpec observations will enable a wide range of AGN-related science. We will use a combination of X-ray data and CEERS MIRI and NIRSpec data to create a multiwavelength sample of AGN and use it to conduct the following science: (1) NIRCam imaging will provide rest-frame optical morphologies of AGN hosts at z=2-6. We will trace the emergence of bulge and disk structures and their connection to SMBH growth during the era of galaxy assembly and determine the role that galaxy mergers play in fueling AGN activity during this epoch. (2) We will use MIRI color diagnostics to perform a census of obscured SMBHs out to z=2, revealing the properties of this previously hidden population and determining how the fraction of obscured AGN evolves with redshift. (3) We will use NIRSpec data to conduct a survey of AGN-driven outflows at z>3 and measure the impact they have on their host galaxies. (4) We will search for the seeds of today’s SMBHs at Cosmic Dawn by using NIRSpec to find high ionization lines from growing SMBHs at z>7. As part of our science analysis, we will release value-added catalogs of morphologies, emission line fluxes, and AGN identifications to supplement the CEERS dataset and directly enable future community use of JWST.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02452
Program Title: The Vanishing Act: PAHs and Heavy Element Abundance in M101
Principal Investigator: JD Smith
PI Institution: University of Toledo
Colinvestigators
Alberto Bolatto University of Maryland, Karin Sandstrom University of California - San Diego, Evan Skillman University of Minnesota - Twin Cities, Martha Boyer Space Telescope Science Institute, Thomas Lai University of Toledo, Bruce Draine Princeton University, Karl Gordon Space Telescope Science Institute, Brandon Hensley Princeton University, Desika Narayanan University of Florida, Ilse De Loop Universiteit Gent

One of Spitzer’s hallmark extragalactic discoveries was the sensitive dependence of PAH emission on metallicity. PAHs seem simply to vanish in galaxies below approximately one-quarter of the solar abundance. Understanding the physical origin of this unexpected phenomenon is urgent, and will have major implications for all upcoming JWST proposals using the mid-IR PAH bands to trace star formation at high redshift.

We outline a modest imaging-only program to map the 3.3μm PAH feature along a radial strip in the galaxy M101, beyond 1/5th solar metallicity. M101 is the ideal laboratory for this simple experiment. Thanks to impressively deep 8m-class "auroral-line" spectroscopy from the CHAOS program, M101’s steep radial abundance gradient is the most accurately known of any galaxy in the Universe. Additionally, ~50 hours of ultra-deep Spitzer/IRS mapping spectroscopy probe a strip extending 20kpc from its center. Spitzer provided no access to the shortest and highest excitation 3.3μm PAH feature. This band provides a crucial missing piece of the puzzle since it is highly diagnostic of the very smallest PAH grains which are most likely to be affected by changes in low-metallicity environments. NIRCAM’s high surface brightness sensitivity and perfectly matched filter set enable a deep measurement of 3.3μm PAH emission at ~4pc resolution, simultaneously tracing signs of mechanical heating with H_2 2.12μm narrowband imaging. Armed with new models for PAH band variations driven by grain destruction, inhibited formation, and changes in the starlight spectrum, we can definitively answer: how & why do PAH grains respond so sensitively to the varying heavy metal content of galaxies?
Super-puffs are a distinct class of low mass, large radii planets that challenge models of planet formation and evolution. Their inferred large gas mass fractions suggest that they formed at large semi-major axes, beyond the water iceline, and migrated to their current locations among the similar-mass but much more abundant sub-Neptunes. Their large gas mass fractions also make super-puffs vulnerable to catastrophic atmospheric loss, which makes their continued existence a mystery. A possible solution to the problems faced by super-puffs is that they are enshrouded in high altitude haze layers that make them look bigger than they would look if they had clear atmospheres. Hubble Space Telescope observations of three super-puffs lend credence to this hypothesis, as they showed featureless transmission spectra. We propose to observe the 0.6-5.3 micron transmission spectrum of the super-puff Kepler-51b using NIRSpec PRISM to test the high altitude haze hypothesis and also to search for spectral signatures of diagnostic gases and haze composition. We will also be able to test alternate hypotheses for super-puffs' large radii and featureless NIR transmission spectra, including high atmospheric metallicity coupled with a high internal heat flux and the existence of planetary rings. Detection of any haze spectral features will constrain their composition and help guide laboratory haze experiments. Measurements of gas spectral features will for the first time give us information on super-puffs' atmospheric composition, which will shed light on whether they have suffered atmospheric loss and whether they migrated from beyond the water iceline.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02457
Program Title: Extreme quasar feedback at the peak of the galaxy formation epoch.
Principal Investigator: Andrey Vayner
PI Institution: The Johns Hopkins University
CoInvestigators
Nadia Zakamska The Johns Hopkins University, Fred Hamann University of California - Riverside, Dominika Wylezalek Zentrum fur Astronomie - Universitat Heidelberg, Serena Perrotta University of California - San Diego

Feedback from accreting supermassive black holes is now a standard ingredient in galaxy formation models. It may be necessary for recreating the steep high-mass end of the stellar mass function and for establishing the black-hole/bulge correlations. Powerful ionized gas winds are a ubiquitous feature in luminous obscured $z = 0.5$ quasars. We now propose to explore quasar outflows at the peak epoch of galaxy formation and quasar activity, when quasar winds must have made the strongest impact on galaxy formation. We request NIRSpec integral field spectroscopy observations of 5 near-Eddington red quasars at $z \sim 2.5$ with extreme ($\gg 1000$ km/s) outflow activity, well beyond that seen at low redshifts. We will observe Hbeta+[OIII] and Ha+[NII]+[SII] in a single configuration per target at an 0.8 kpc resolution. We will measure the energetics of the outflows to gauge their driving mechanism and whether they have the necessary coupling efficiency in establishing the local correlation between the mass of the black-hole/bulge. We will perform resolved ionization diagnostics to isolate regions within each host galaxy photoionized by the quasar, shocks from the outflows, and recent star formation. We will map the location of powerful outflows and compare them to recent star formation locations to see if regions of powerful outflows coincide with low star formation regions. With their unprecedented [OIII] kinematics, red quasars may be the signposts of the extreme "blow-out" phase of quasar feedback that is expected to affect star formation significantly. NIRSpec-IFU observations will allow us to test this hypothesis definitively.
 Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02459
Program Title: Completing the puzzle of interstellar dust grain compositions: combining extinction, depletion and molecular hydrogen measurements
Principal Investigator: Marjorie Decleir
PI Institution: Space Telescope Science Institute
CoInvestigators: Karl Gordon Space Telescope Science Institute, Julia Roman-Duval Space Telescope Science Institute, Karl Misselt University of Arizona

We propose to observe a carefully selected sample of 9 stars in the Milky Way with the NIRCam Grism Time Series mode and the MIRI Medium Resolution Spectrograph to measure dust extinction curves from 2.4 to 28 micron. The continuum extinction will provide a measurement of the dust grain size distribution, while the absorption features in the extinction curve reveal details about the chemical composition of the dust grains. Combining these near- and mid-infrared extinction curves with UV extinction curves, depletion measurements and molecular hydrogen fractions, will place much stronger constraints on the grain composition and its variation between sightlines than could ever be derived from these individual measurements. The proposed observations are currently the last missing piece to complete the puzzle.
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02473
Program Title: Multiplicity Survey of 20 Y Dwarfs with NIRCam Kernel Phase Interferometry
Principal Investigator: Loic Albert
PI Institution: Universite de Montreal

ColInvestigators
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The WISE infrared survey uncovered the coolest sub-stellar objects, brown dwarfs of type “Y”, and a precious set of ~25 Y-dwarfs have been spectroscopically confirmed to date. These brown dwarfs personify the extremes and are the coolest (<500 K), least massive (5-30 M_Jup) and, surprisingly, most abundant sub-stellar objects (Kirpatrick et al. 2019). But Y dwarfs are extremely hard to study from the ground, i.e. they have limited light output below 4 microns and the Earth’s atmosphere is opaque near the peak of their spectral energy distribution at 5 microns. Are Y dwarfs single or can they support companions? Is their a minimum companion mass? Can giant planets be formed around Y dwarfs? We propose to unleash JWST’s potential by determining the multiplicity rate for a sample of 20 Y-dwarfs with sub Jupiter-mass sensitivity. Using a powerful technique for analyzing NIRCam images, Kernel phase interferometry, we will search for companions with large magnitude differences at sub-AU resolution. We will measure the Y-dwarfs companion-to-host mass ratio distribution, q, to unprecedented low values (q<0.1), constrain the orbital distribution of companions down to ~0.5 AU and be sensitive to potential giant planets. We expect an average yield of 3 companions. This survey could discover an object cooler than 250 K, thereby bridging the gap between the coldest known Y dwarf, WISE 0855 (250 K) and Jupiter (130 K). The determination of dynamical masses, vital for advancing our knowledge of Y dwarfs, will be possible within JWST’s lifetime. The goals of our observational program can only be achieved with JWST because of its exquisite sensitivity at 5 microns.
The launch of JWST opens the door for our first window on the stars and gas in the galaxies of the reionization era. The typical galaxies in this early period are low mass star forming systems. The planned Cycle 1 NIRSpec surveys will build large statistical samples of these galaxies, but because of their faintness ($H=27-29$) the spectra will not yield useful insight into their stellar populations or gas conditions. Progress requires coupling the large statistical surveys with extremely deep spectra of low mass galaxies. Here we propose to accomplish this goal via NIRSpec MSA observations of a sample of reionization-era dwarf galaxies that are highly magnified by gravitational lensing. Our primary targets include two $z>6$ galaxies already known to power strong CIV emission, potentially pointing to a population of extremely low metallicity and very massive stars or the common presence of AGN in dwarf $z>6$ galaxies. Such intense high ionization nebular emission is unprecedented locally but appears to be a typical feature in the low mass population at these early epochs. The proposed rest-UV to optical spectra will reveal what the high ionization nebular lines are telling us about the ionizing sources and gas conditions in early low mass galaxies. We will simultaneously observe a large number of reionization-era galaxies in the cluster fields, including up to 7 of the brightest ($H=23.8-25.6$) dwarf galaxies known at these redshifts. The proposed spectra will characterize the metallicity, outflows, and ionizing sources in a representative range of low mass $z>6$ galaxies, providing our most detailed view of the galaxies which are typical in the reionization era.
Deep HST images of strongly lensed clumpy galaxies at redshift z~1-3 shows UV-bright clumps, on average, 100x more massive than local star cluster complexes. Their physical properties supports an in-situ clump formation under fragmentation of turbulent, marginally stable high-redshift gas disks. Among these galaxies, the Cosmic Snake, a strongly lensed clumpy galaxy at z=1.036, resolved down to physical scale of 30-70 pc in HST images (0.13''), sets a record of hosting 21 stellar clumps (HST rest-frame UV/optical) and 17 giant molecular clouds (GMCs) in ALMA CO observations at matched HST resolution. These GMCs have gas masses high enough to allow for the formation of the massive stellar clumps. The comparison of GMCs and stellar clump masses suggests a GMC star formation efficiency (~30%) much higher than observed in contemporary galaxies (<6%). If confirmed, it would suggest an evolution in the efficiency of forming stars with redshift. We propose to use an independent approach to derive the star formation efficiency of Cosmic Snake GMCs based on a statistical framework recently applied to nearby galaxies, which translates cloud-scale variations of the flux ratio between tracers of molecular gas and star formation to the molecular cloud evolutionary timeline, necessary to reliably determine the cloud-scale star formation efficiency. This framework relies on a tracer of very recent star formation, therefore we request for NIRSpec IFU Ha mapping of the Cosmic Snake galaxy to spatially (~0.1'') cross-match young HII regions, traced by Ha, and molecular clouds.
High angular resolution observations of planet forming disks are revealing a wide variety of disk substructures, predominantly azimuthally symmetric rings and gaps. Such morphologies can be readily explained as the secular outcome of planet-disk interactions, suggesting a large population of unseen planets. This scenario is also supported by kinematic studies of protoplanetary disks, which are revealing substantial deviations from Keplerian rotation characteristic of embedded giant planets. To test this scenario, a direct detection of an embedded planet is needed. We propose to use NIRCam to detect such a planet in the disk around AS 209. The circumstellar material exhibits a clear gap in the 12CO emission at a large orbital separation from the central star (210 au; 1.7"), indicating an extremely deep gap in the disk gas surface density. This is consistent with a kinematic analysis showing a large pressure minimum at the center of the gap. The only mechanism known to produce such a feature in the gas surface density is a massive planet (~2 M_Jup) opening a gap. The large gap depth and width and lower inclination of the disk are highly favorable conditions for detecting an embedded planet as extinction from disk material along the line of sight will be minimized. Using 3D numerical simulations of a bespoke AS 209 model as the basis for simulated observations, we find we will reach a 5 sigma sensitivity of ~0.2 M_Jup at the location of the CO gap. As secondary goal, we will search for the planet generating the mm continuum rings at 0.8", where we obtain a 5 sigma sensitivity of ~0.5-1 M_Jup, far surpassing any limits achievable with ground-based facilities.
Clouds are found on all Solar System planets with substantial atmospheres and are likely prevalent amongst most exoplanets as well. Although it is clear that clouds have a significant impact on observations of exoplanetary atmospheres, our understanding of the fundamental cloud physics that dictate their compositions, particle sizes, and formation/dissipation timescales is relatively poor. We are proposing to use NIRSpec to observe the eclipse and periapsis passage (~18 hrs) of HD80606 b, a hot Jupiter characterized by one of the highest eccentricities (e=0.93) of any known exoplanet, in order to study cloud dynamics. The planet’s atmosphere undergoes dramatic temperature changes as it approaches periapsis (from <500 K to ~1400 K) and, as a result, the distribution of clouds is expected to vary rapidly due to evaporation/sublimation. The observations will place important constraints on cloud composition and condensation predictions as well as formation/dissipation timescales. The high brightness and extreme eccentricity of HD80606 b makes it an ideal laboratory for studying cloud dynamics and cloud properties as a function of incident radiation; the proposed observations have the potential to provide future atmospheric characterization studies with a powerful means by which “cloud-free” targets can be accurately identified.
Despite the need for very high gas densities to overcome the tidal field of the supermassive black hole (Sgr A*) and induce gravitational collapse, there is increasing evidence for star formation taking place at the heart of the Milky Way. With the superb capabilities of the JWST MIRI MRS integral field spectrograph, we will finally be able to test the hypothesis of low-mass star formation at the Galactic Centre (GC). We propose to observe a group of faint mid-infrared sources in the nuclear star cluster to uncover their true nature. Their extreme infrared excess and spectral indices (based on long integration VLT L- and N-band data) and their association with photoevaporative protoplanetary disk-like counterparts in the radio, make them prime candidates for embedded low-mass young stars, located just about 0.5 pc in projection away from Sgr A*. Only MIRI MRS will be able to study and even characterise these sources in such unprecedented detail that was only possible so far for nearby star forming regions. Confirming the presence of low-mass young stars at the GC has implications on disk dispersion time-scales in dense clusters, which opens up the potential for planet formation in the tidally stressed environment of galactic nuclei.
Transmission spectroscopy measurements of exoplanets have rewritten our understanding of the atmospheres of giant planets. However, existing observations provide little direct information about how these atmospheres form or evolve, as the overwhelming majority of well-characterized systems are old or have unknown ages. We propose for JWST/NIRSpec BOTS transmission spectra of the recently-discovered young hot Jupiter, HIP 67522 b (17 Myr). The proposed transmission spectra of this young planet can be compared to the plethora of existing HST, and planned JWST data available on its older analogues, providing more direct constraints on the origins of features seen in mature hot Jupiters. Since the planet retains its natal atmosphere, we can detect chemical patterns that reveal where the planet formed in the disk. Thus, HIP 67522 b offers an exceptional window into the formation and early evolution of planetary systems.
We request 1.5 hours of JWST observations to characterize a newly discovered planet around the white dwarf star WD 1856+534. The planet, called WD 1856 b, is about the size of Jupiter and has a mass less than 14 times that of Jupiter at 95% confidence. The planet orbits only 0.02 AU from the white dwarf, close enough that it must have originally orbited beyond 1 AU and migrated inwards to avoid being engulfed when the progenitor star evolved into a red giant. How the planet may have migrated is an active area of debate. We propose to use JWST/NIRSPEC to detect features in WD 1856 b's thermal emission spectrum. A detection will measure the planet's mass and probe the atmospheric composition, while a non-detection provides tight enough constraints on the planet's mass to rule out certain formation scenarios. Either way, JWST observations will help us understand this unique planet and the processes that shape planetary systems after the main sequence.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02508
Program Title: The First and Only Multi-wavelength Map of an Ultra-short-period sub-Earth

Principal Investigator: Michael Zhang
PI Institution: California Institute of Technology
CoInvestigators
Heather Knutson California Institute of Technology, Fei Dai California Institute of Technology, Renyu Hu Jet Propulsion Laboratory, Kristine Lam The University of Warwick

We propose to obtain a spectroscopic (5–12 um) phase curve of GJ 367b (TOI 731.01), an iron-rich 0.72 R_earth, 0.53 M_earth sub-Earth. GJ 367b is likely to forever remain the most observationally favorable sub-Earth outside the solar system, and the only one accessible to study by JWST. The phase curve will constrain the planet's dayside and nightside temperatures, phase offset, Bond albedo, and heat recirculation efficiency. A significant atmosphere would manifest as a diminished day-night temperature contrast, non-zero phase offset, and if there are clouds, high albedo. If there is significant eccentricity, the resulting tidal heating would be visible as anomalously high thermal emission. If there is no atmosphere, observations may be capable of distinguishing between different surface compositions. A metal-rich primary crust, for example, would be featureless and have higher brightness temperature, while an Earth-like granitoid tertiary crust (created by plate tectonics) will have lower brightness temperature, with an absorption feature at 8–10 um. Our observations would shed light on the properties and origins of iron-rich ultra-short-period planets, and serve as a pathfinder to future studies of the planet.
Proposal Category: AR
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02509
Program Title: Kernel-Phase Detection Limits for Planet Discovery with JWST
Principal Investigator: Samuel Factor
PI Institution: University of Texas at Austin
Co Investigators: Adam Kraus University of Texas at Austin

Filling the dearth of detections between directly-imaged and RV planets will test theories of planet formation across the full range of semi-major axes, connecting formation of close to wide separation gas giants and substellar companions. Direct detection of close-in companions is notoriously difficult: coronagraphs and PSF subtraction techniques are limited in separation and contrast. Non-redundant aperture masking interferometry can reveal companions well inside the PSF of a diffraction limited image, but the technique is severely flux-limited since the mask discards 95% of the gathered light. Kernel-phase interferometry applies similar interferometric techniques to an unobscured diffraction limited image, simulating the full telescope aperture as an interferometer composed of a grid of subapertures. We have developed a new faint companion detection pipeline using Bayesian model comparison of kernel-phases. We have demonstrated this pipeline on HST/NICMOS images of nearby brown dwarfs, refining astrometry of previously known companions and finding new companions. We have also characterized the detection limits, demonstrating significant sensitivity down to flux ratios of $\sim 10^{-2}$ at half L/D, reaching the planetary-mass regime for young targets. We now propose to apply modify our pipeline for use with JWST and apply it to PSF calibration targets observed through engineering, GTO, and DD-ERS programs. We will measure the detection limits of the kernel-phase analysis technique and determine best practice observing strategies in future cycles. Our pipeline will be made publicly available for straightforward kernel-phase analysis of imaging and AMI data.
We propose to explore the properties of small dust grains in a prototypical blue compact dwarf II Zw 40 using a single pointing of the NIRSpec and MIRI IFUs. II Zw 40 has been found to exhibit strong 3.3 micron emission powered by the smallest polycyclic aromatic hydrocarbons. This challenges the prevailing theory that small and fragile grains are to be suppressed in low-metallicity galaxies due to the penetrating UV radiation. We will directly investigate how PAH size distribution and ionization state connect with the hardness of the radiation field in a compact starbursting region in II Zw 40, with a spatial resolution of 5 pc offered by the IFU. To study the life cycle of dust in metal-poor galaxies, we will measure the relative abundance of the dust in aromatic and aliphatic forms to understand the formation and destruction process of dust near the star-formation site. Further, the gas-to-dust ratio varies substantially in low-metallicity environments. With the mid-infrared H2 rotational lines, the total molecular gas mass can be estimated independently, without using CO line emission. Comparing our results with the available ALMA CO observations can provide insights into the variation of the H2-to-CO conversion factor in II Zw 40.
The last decades of exoplanet exploration have revealed that the diversity of planets within the Galaxy far exceeds that within our solar system. Specifically, Kepler revealed a new population of 1-3 Earth short period planets that seem to bridge the gap between giants and terrestrials in our own bimodal planetary system. Their bulk properties imply diminishingly thin hydrogen envelopes, producing an intermediate physical state between planets with predominantly primordial atmospheres and those with secondary atmospheres. However, we lack observations to determine whether this is truly the case, how such atmospheres are produced, and how similar or different they are to solar system planets. Atmospheric composition provides the necessary additional dimension to unveil the nature of this new class of planet, which we maintain will be JWST’s greatest exoplanet legacy. We have carefully constructed the first exoplanet atmospheres survey designed to build a critical link between atmospheric characterization and planetary demographics. We will observe 11 transiting exoplanets, including four pairs of planets in the same system. By utilizing JWST’s unique capabilities, we will measure the relative abundances of major molecular species expected to provide key insights into the formation and evolution pathways of exoplanets. Through our holistic approach we will analyze planets individually, within their own system architectures, and ultimately as a population. This will culminate in a program that will provide the community with a necessary kickstart to future information-rich observations of small planets, and will ultimately sculpt JWST’s lasting legacy.
Proposal Category: GO  
Scientific Category: Galaxies  
ID: 02514  
Program Title: PANORAMIC -- A Pure Parallel Wide Area Legacy Imaging Survey at 1-5 Micron  
Principal Investigator: Christina Williams  
PI Institution: University of Arizona  

ColInvestigators  
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Where HST has characterized the UV universe to z=6-7 and beyond, JWST is designed to take the crucial next step and characterize the UV universe to z=12-15 (a factor of 2 in expansion rate), at only ~300 Myr after the Big Bang where we expect the first galaxies to form. Additionally, JWST for the first time allows studies of the restframe optical emission to z=10, a huge leap from the current z=3 (HST). To fully capitalize on JWST’s unparalleled imaging AND spectroscopic capabilities, it is critical, however, to find the most precious intrinsically luminous candidate galaxies early in the mission. Large area imaging is thus needed from day one. Here, we propose to exploit the unique opportunity offered by pure parallel observing to efficiently obtain such a wide-area reference survey over 0.4 sq degrees in 6 NIRCam filters. By probing 7x larger area than any other currently planned (GTO/ERS) program our survey will probe a unique discovery space with unprecedented imaging at 1-5micron. These data overcome two major outstanding limitations in our current extragalactic census using yet undiscovered populations: (1) the brightest and most distant sources that ended the cosmic Dark Ages at z>9 and (2) red sources at 3<z<7 including both dusty and quiescent galaxies. However, our survey is designed to result in an outstanding multi-wavelength legacy dataset for the community enabling a wide range of science based on an estimated 1 million galaxies, from the local universe to the first sources. We will deliver reduced data and high-level catalogs which can be used by the full community for rapid spectroscopic follow-up.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02516
Program Title: Revealing the hidden stellar emission in the highest-fidelity ALMA-mapped submillimeter galaxies
Principal Investigator: Jacqueline Hodge
PI Institution: Universiteit Leiden
Col Investigators: Elisabete da Cunha, International Centre for Radio Astronomy Research, Paul van der Werf, Universiteit Leiden, Fabian Walter, Max-Planck-Institut für Astronomie, Heidelberg, Matus Rybak, Sterrewacht Leiden, Marta Frías Castillo, Universiteit Leiden, Sarah Leslie, Universiteit Leiden, Ian Small, Durham Univ., Mark Swinbank, Durham Univ., Sarah Kendrew, Space Telescope Science Institute, Gabriela Calistro, Rivera; European Southern Observatory, Germany, Julie Wardlow, Lancaster University, Chian-Chou Chen, European Southern Observatory, Germany, Eva Schinnerer, Max-Planck-Institut für Astronomie, Heidelberg

Twenty years after their discovery, the nature of the most highly star-forming galaxies in the universe remains a mystery. Despite forming stars at 100s-1000s M_{\odot} yr^{-1}, these z\sim2.5 submillimeter-bright galaxies (SMGs) are notoriously difficult to study with optical telescopes due to their extreme dust obscuration, rendering them faint/invisible even in deep HST H-band imaging, and leading to decades of debate on whether major mergers are necessary to trigger their starbursts. Recently, ALMA has revolutionized the field by revealing the obscured star formation in SMGs in unprecedented detail. Here we propose NIRCam+MIRI imaging at 2-7\um of 12 SMGs with unrivaled high-S/N ALMA continuum imaging, which span a range in redshift and SFRs reflective of the larger SMG population. By detecting and resolving the stellar emission at rest-frame ~500\AA to (crucially) 2\um— a jump of a factor of 5 in rest-wavelength over the HST H-band— these observations will put first constraints on the underlying morphologies of the stellar emission in these sources, and at a resolution that is perfectly matched to that of the high-S/N ALMA imaging. This proposal will provide maps of resolved stellar mass and star formation rate (and thus, the specific star formation rate), and will yield first reliable total masses for this historically unconstrained population. These observations will provide the context necessary to interpret the ALMA-revealed star formation and its ability to morphologically transform SMGs into their proposed descendants - massive local elliptical galaxies.
We propose the first ever near- to mid-infrared observations of the resolved structure of a low-metallicity photodissociation region (PDR). PDRs are fundamental to ISM physics and the source of a major fraction of all galactic line emission. They describe much of the molecular gas and essentially all of the atomic gas in galaxies. The first resolved maps of the Orion Bar by Tielens et al (1993), showing the transition from ionized to atomic to molecular gas using near- to mid-IR observations, became a benchmark for PDR models. Low metallicity PDRs are expected to be very different, due to the competing effects of enhanced FUV penetration due to low dust abundance, deficits in heating from the photoelectric effect from dust and photoionization by metals, and deficits in cooling due to lower abundance of elements that emit fine structure lines. With the extraordinary resolution of JWST in the near- to mid-IR we can now observe a PDR in the nearest low metallicity galaxy, the Small Magellanic Cloud, at comparable sub-pc resolution to the original Orion Bar observations. Using the NIRSpec and MIRI IFUs, we will map the resolved layers of the PDR in the N13 star-forming region of the SMC, a simple, edge-on PDR similar to Orion. We will measure temperatures, ionization structure, density, and PAH size and charge and use these to provide vital constraints for PDR models. These observations will reveal the inner workings of this key ISM component at low metallicity and are only possible in the Small Magellanic Cloud and with the angular resolution and sensitivity of JWST.
In this JWST data archive project, we propose to model mid-infrared MIRI MRS spectra of Titan acquired under GTO project #1251 ("Titan Climate, Composition and Clouds") with the goal of detecting new chemical species in Titan’s atmosphere. In particular, we will focus on the 5-7 micron spectral range, which has not been previously seen by either of Cassini’s infrared spectrometers or other observatories. This spectral range contains molecular bands of many organic molecules previously unseen in Titan’s atmosphere, which may be detected for the first time by virtue of JWST’s very high sensitivity. Such new detections would greatly contribute to our knowledge of Titan’s organic chemistry, and to the wider field of astrobiology.
The results of Herschel and Spitzer imaging surveys of nearby Galactic clouds suggest that most stars form in dense molecular filaments, which are often dark at near-IR to mid-IR wavelengths. The Herschel results support a filament paradigm for at least solar-type star formation, whereby Jeans-like fragmentation of 0.1-pc-wide supercritical filaments produces < 0.1 pc prestellar cores, which subsequently collapse to protostars. The validity and details of this paradigm are much debated, however, and the detailed fragmentation manner of filaments remains a puzzle. Despite ongoing debates, the properties of dense filaments are thought to be representative of the initial conditions of most star formation in the Galaxy. We propose to exploit the unique resolution and sensitivity of JWST in the mid-IR to determine the radial density structure and fragmentation spacing properties of a sample of 6 infrared-dark filaments at different locations in the Galactic disk with unprecedented accuracy. The proposed observations will resolve the thermal Jeans length < 0.02 pc, provide a deep census of starless dense cores down to the Jeans mass, and determine the core mass function in each filament. The results will be compared with numerical simulations of filament fragmentation. They will be used to test the simple picture, tentatively suggested by recent ALMA findings, that the average filament width and core spacing remain roughly the same in all filaments, but that the typical core mass scales ~ linearly with the line mass of the parent filament. If confirmed by the proposed MIRI study, this will have profound implications for our understanding of the origin of the initial mass function.
We propose to do analysis of the low-albedo asteroid data being collected as part of JWST Guaranteed Time Programs #1244 and #1245: NIRSpec Prism spectra for the Trojan asteroids Hektor and Patroclus and both NIRSpec Prism spectra and MIRI MRS spectra for the main-belt asteroids Ceres, Pallas, and Hygiea and the near-Earth asteroid Phaethon.

The data will be used to address the following broad science questions, as detailed below:
1. What is the range of hydrated mineral composition and amount of hydrated material present on the surfaces of low-albedo asteroids?

As well as a “data handling” question:
2. How can useful spectral information best be extracted from saturated JWST data?

The GTO programs mentioned do not include support for analysis, have no exclusive access period and are open for AR proposals in Cycle 1 (see “JWST Cycle 1 GTO Observations Available for Archival Proposals” in JDox). Support for any analysis of these data will need to come either from this program or from some alternate source that considers it in bounds. In addition, the tasks we propose (extraction of spectra from saturated data and modeling of the thermal emission from the objects to allow separate study of the reflectance and emission spectra) will not be part of a standard JWST reduction pipeline, but will be necessary to allow the proper interpretation of the NIRSpec data and any use of the main belt asteroid MIRI data.
Using the MIRI Four-Quadrant Phase Mask Coronagraph operating with the F1550C filter, we will directly image the massive planets that are responsible for sculpting the sharp inner edges of nearby debris disk systems that have been imaged with ALMA. We use semi-analytical models to derive a lower limit on the planet mass, as well as an outer estimate to the planet orbital separation. To estimate our sensitivity to planets, we use the most up-to-date simulations of MIRI coronagraphic performance to generate detection probability maps for our observations. Comparing these estimates of our expected sensitivity with MIRI to the predicted mass and separations of the planet in the system allows us to identify three systems (GJ14, HD207129, and HD202628) in which we will have a high confidence of detecting a planet in each of the three systems with expected masses ranging from ~0.3 to 1.0 Jupiter masses. Not only will the identification of these planetary mass companions provide clear evidence that they are indeed responsible for sculpting the dust disk, but such objects will be ideal for subsequent follow-up observations for atmospheric characterization using the suite of wavelengths afforded by JWST.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02540
Program Title: Investigating the Disk-Planet Interaction in the HD 163296 System with JWST
Principal Investigator: Luca Ricci
PI Institution: California State University - Northridge

Co-Investigators
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We propose JWST/NIRCam observations of the planet-forming disk orbiting the young Herbig Ae star HD 163296. Recent high resolution ALMA observations have unveiled concentric annular gaps in the distribution of mm-sized pebbles at angular distances of 0.1, 0.5, 0.9, 1.5 arcsec from the central star. The two outer dust gaps show depletion also in CO gas, suggesting the possible presence of Jupiter-mass giant planets to gravitationally clear material out of their orbit. If so, also micron-sized grains should be severely depleted at the location of the two outer gaps. Moreover, the analysis of high angular and spectral resolution observations with ALMA of the CO molecular line emission have found significant discrepancies from the Keplerian rotation of the disk. Also these kinematical features have been attributed to the interaction with giant planets that would affect the 3D velocity of gas in the disk, but this scenario still lacks empirical confirmation. This hypothesis can be directly tested via the proposed NIRCam coronagraphic observations, which have the potential to detect the emission from these young giant planets.

Given the angular separations and characteristics of the multiple substructures detected in both the density and kinematics of this disk, HD 163296 represents an ideal testbed system to demonstrate the potential of JWST, in synergy with ALMA, to test models of the disk-planet interaction and planet formation.
Quasar outflows are among the leading internal negative-feedback processes to explain the inside-out quenching of star formation in massive galaxies and the tight SMBH-spheroid mass relation. The likely culprits, the fast-accreting quasars, are common at the epoch of peak SMBH accretion but rare locally, making it hard to catch and study this negative-feedback phenomenon in action, even with JWST. Fortunately, there is one spectacular exception: PDS 456, the most luminous quasar in the local universe. Clear unambiguous signatures of outflows have been detected in this object on all scales, ranging from the X-ray/UV-detected relativistic wind on sub-pc accretion-disk scales to the galaxy-wide warm-ionized and cold-molecular outflows which extend to at least 10 kpc. The energetics of the outflow indicate that it is potentially able to rapidly quench star formation in the host although the current observations are still missing the critically important coronal-ionized, neutral-atomic, and warm-molecular gas phases to determine if the quasar actually affects the host evolution. The proposed NIRSpec and MIRI data cubes, analyzed with the highly optimized PSF decomposition software package IFSFIT, will allow us to (1) get an accurate and complete census of the outflow energetics, (2) constrain the dominant mechanisms that drive this outflow and AGN duty cycle, and (3) characterize the impact of the quasar outflow and intense radiation field on the physical state of the host ISM, coeval star formation activity, and circumgalactic medium. These exquisite data will serve as a local template to help interpret the coarser data from scheduled GTO/ERS JWST studies of distant quasars.
Trojan asteroids, which librate around a planet’s L4 or L5 point, are thought to be remnants of our primordial disk as the strong 1:1 resonance means they can be stable on order the age of the Solar System. This resonance relationship means that Trojans are also tied to the evolution of their planet, meaning that giant planet Trojans can also be used to constrain planetary migration models. Neptune Trojans (NTs) are a particularly puzzling population; while they are expected to have a mix of red and ultra-red surfaces, only one ultra-red NT has been discovered to date. It is possible that collisions between NTs and Plutinos shifted the NT colors blueward over time, but colors are limited in their capacity to answer this question as a variety of processes and compositions can affect the colors of planetary bodies, often in ways that are indistinguishable from each other. Near-IR spectra can provide more information about these planetary surfaces as many broad molecular absorption features occur at these wavelengths. In particular, these features can be used to measure ice composition, ice irradiation products, surface grain size, and the ice phase. Therefore, we propose to take the first near-IR spectroscopic survey of NTs in order to study the ultra-red NT’s surface in more detail, compare L4 and L5 NTs, and compare unstable NTs to Centaurs. JWST is vital to this program as these objects are too faint to take reasonable spectra using ground-based facilities. Regardless of the exact outcomes, these measurements would lead to a better understanding of the formation and evolution of NTs and the giant planets.
JWST Cycle 1 Abstract Catalog

Proposal Category: AR
Scientific Category: Supermassive Black Holes and AGN
ID: 02554
Program Title: AGN Feeding and Feedback in NGC 4151

Principal Investigator: Francisco Mueller-Sanchez
PI Institution: University of Memphis
Co Investigators
Erin Hicks University of Alaska Anchorage, Matthew Malkan University of California - Los Angeles, Misty Bentz Georgia State University Research Foundation, Mason Ruby University of Memphis

The discovery of a number of black hole (BH) galaxy relations has shown that the growth of supermassive BHs is closely related to the evolution of galaxies. This evidence has opened a new debate in which the fundamental questions concern the interactions between the central BH and the interstellar medium within the host galaxy, and can be addressed by studying two crucial processes: feeding and feedback. Using archival JWST NIRSpec data, we aim to characterize the circumnuclear region of NGC 4151 to study, with unprecedented detail AGN feeding and feedback. NGC 4151, as one of the nearest AGN and an extremely well-studied Seyfert galaxy, provides an outstanding opportunity to obtain meaningful constraints for models incorporating these processes to regulate BH-host galaxy co-evolution. We will achieve this by: (1) tracing outflows via ionized and coronal gas emission to establish the energetics of the outflowing gas and potential for feedback into the host galaxy, (2) tracing inflows via molecular hydrogen gas emission from which the driving inflow mechanism can be identified and an inflow rate obtained via modeling, (3) using the wide range of available H2 lines in the near-IR to establish their connection with the obscuring torus, and (4) obtaining a molecular gas-based black hole mass estimate. JWST is uniquely capable of advancing our understanding of these processes due to its sensitivity and stable point-spread-function, which facilitates the detection of diagnostic emission lines not available in current ground based data, as well as probing these processes down to unprecedented spatial scales.
Proposal Category: GO
Scientific Category: Galaxies
ID: 02555
Program Title: How do ionizing photons escape the Sunburst Arc?
Principal Investigator: T. Emil Rivera-Thorsen
PI Institution: Stockholm University

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How the early Universe was reionized is a key science case for JWST. The majority of ionizing Lyman Continuum (LyC) photons were produced by massive stars in the first galaxies, and had to find their way through the neutral ISM and escape into intergalactic Space. How this happened is unclear, and due to the high fraction of neutral gas in the IGM, we cannot study ionizing escape directly at z>4, but must rely on lower redshift analogs.

In the local Universe, escape fractions are far too low to account for the energy needed to cause reionization. In order to determine which physical processes regulate ionizing escape, and how they can evolve over cosmic time, we need to study the ISM of leaking galaxies in high detail, across Cosmological epochs.

We propose deep NIRSpec IFU observations and supplementary NIRCam imaging of the gravitationally lensed “Sunburst Arc” (z=2.4), the only galaxy at z>0.1 for which such a study is possible. The galaxy is an extremely bright LyC leaker, and despite its enormous distance, the only known galaxy where the origin of LyC is pinpointed down to ~10 pc. The proposed observations will enable detailed mapping of the production sites of ionizing radiation, as well as possible escape paths, and detailed mapping of kinematics, ionization and other parameters that will reveal which mechanisms regulate the escape, and how they differ from the local Universe.

These observations will be a unique connecting link between local analogs and the Epoch of Reionization, and will be a valuable reference dataset long after the end of JWST’s mission.
Globular clusters are the oldest assemblages of stars in our Galaxy. Their roughly coeval populations, sharing the same composition and distance from Earth, are ideal laboratories to test out theories of stellar evolution. We here propose to observe the globular cluster 47 Tucanae, one of the richest and most carefully observed clusters in our Galaxy, to observe for the first time the cooling brown dwarf sequence and to hunt for ancient planetary systems around white dwarfs. A sample of brown dwarfs that are well characterized in age, distance and metal content will help break the degeneracies that plague current brown dwarf observations and will provide an important test sample for theoretical models of these objects. Additionally, the location of the brown dwarf sequence in the JWST CMD presents a new method for estimating the age of the cluster itself. With the same observations, we will have a large sample of hot white dwarfs, between 9,500–K and 25,000–K, of which about 5\% are expected to show the presence of a debris disk if the population is similar to that of the field. On the other hand, observing the faint end of the white dwarf cooling sequence in the infrared will lead to a better understanding of atmospheric properties and systematic issues in our current models.
Since its discovery, the multiple population phenomenon is an enigma in the field of stellar populations. We propose combined spectroscopic and photometric JWST observations that will finally solve this long-standing issue. So far, two competing scenarios are available: 1) multiple bursts of star formation; 2) accretion of material onto existing stars. In the first scenario the population pattern is expected to be identical for stars with different masses, while the accretion scenario should result in substantially more pronounced chemical differences and fractions of second population stars at higher-masses. The exploration of the M dwarf realm and the comparison of the multiple population properties in this very-low mass regime with those of red giants will shed light on the origin of this enigmatic phenomenon. The NIRSpec+NIRCam facilities will provide the unique opportunity to gather spectra and precise photometric diagrams of faint M dwarfs in GCs, not easily accessible to other facilities. Our spectral synthesis and simulated diagrams suggest that the requested data, combined with HST UV archival images, will allow us to infer the O abundance range in the M dwarfs, which will be compared to that observed among red giants, and precise mass functions of multiple populations from ~0.8 solar masses towards the H-burning limit. These first JWST observations will be a milestone in our understanding of such an eluding phenomenon, and a step forward for many closely related issues, e.g. star formation in dense early environments, stellar evolution and nucleosynthesis, the role of proto-clusters in the cosmic reionization and the contribution of GCs to the Milky Way Halo.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02561
Program Title: UNCOVER: Ultra-deep NIRCam and NIRSpec Observations Before the Epoch of Reionization
Principal Investigator: Ivo Labbe
PI Institution: Swinburne University of Technology
Co-Investigators
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We propose an efficient public Treasury program that immediately establishes a NIRCam imaging deep field and ultra-deep low-resolution NIRSpec/PRISM follow-up spectroscopy in the gravitational lensing cluster Frontier Field Abell 2744. Assisted by strong lensing, these observations reach 1-2 magnitudes fainter than even the deepest ERS & GTO programs. Such depths are essential to achieve two core science goals of JWST: finding First Light galaxies during the Dark Ages at z>10 and studying the ultra-low luminosity galaxies at later times that were responsible for reionization. Offering the community early access to deep imaging of 4000 z>6 galaxies and spectroscopy of 500 galaxies ensures that this envisioned flagship science is guaranteed early in the mission, establishes from the start a vibrant and diverse user base for the observatory, and optimizes the efficiency of JWST by providing targets for higher resolution spectroscopic follow up in subsequent cycles. In support of this, we included imaging parallels to enhance the deep imaging legacy on and around the cluster. Beyond the immediate science goals, these data will support a broad array of legacy science including stellar mass complete studies to z=10, the role of dust obscuration at high redshift, and the various pathways of quenching star formation. Our experienced team commits to rapidly releasing the imaging to the public before the Cycle 2 deadline followed by the delivery of a joint photometric and spectroscopic database.

259 3/19/2021
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02562
Program Title: Dust Settling and Grain Evolution in Edge-on Protoplanetary Disks
Principal Investigator: Francois Menard
PI Institution: Institut de Planetologie et d'Astrophysique de Grenoble

Karl Stapelfeldt Jet Propulsion Laboratory, Gaspard Duchene University of California - Berkeley, Marion Villenave Institut de Planetologie et d'Astrophysique de Grenoble, Schuyler Wolff University of Arizona, Marshall Perrin Space Telescope Science Institute, Christophe Pinte Universidad de Chile, Deborah Padgett Jet Propulsion Laboratory

Young, edge-on circumstellar disks are uniquely valuable laboratories for the study of planet formation. With the central star occulted from direct view, the disk is clearly seen as a central dust lane flanked by reflected light from its upper and lower surfaces. The detailed morphology and chromaticity of these nebulae provides crucial information on disk vertical structure and the properties of its constituent dust grains. Spectral energy distributions and very limited ground-based imaging have shown that edge-on protoplanetary disks continue to be dominated by scattered light even out to wavelengths of 20 microns. JWST imaging of these targets therefore offers the unique opportunity to probe the disk interior between the optical scattered light surface seen with HST and the cold midplane emission recently revealed by ALMA. We propose broad-band NIRCam and MIRI imaging of four edge-on protoplanetary disks spanning a range of evolutionary states. The targets are among the largest in angular size of their class and thus should be vertically resolved by JWST even at 20 microns. The images will reveal the wavelength evolution of both the dust lane thickness and the strength of forward scattering, which when interpreted by model fitting will allow us to derive the grain size as a function of height in the disk and thus the extent of dust vertical settling that has taken place. This project will empirically quantify for the first time how the dust concentration increases toward the disk midplane (a necessary condition to efficiently form planetesimals), leaving a legacy of fundamental importance for our understanding of protoplanetary disk evolution.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02565
Program Title: HOW MANY QUIESCENT GALAXIES ARE THERE AT 3<z<4 REALLY?
Principal Investigator: Karl Glazebrook
PI Institution: Swinburne University of Technology

CoInvestigators: James Esaia Swinburne University of Technology, Themiya Nanayakkara Swinburne University of Technology, Juan Espejo Swinburne University of Technology, Colin Jacobs Swinburne University of Technology, Kim-Vy Tran University of New South Wales, Glenn Kapczak Swinburne University of Technology, Pascal Oesch University of Geneva-Department of Astronomy, Ivo Labbe Swinburne University of Technology, Caroline Straatman Ghent University, Casey Papovich Texas A & M University, Corentin Schreiber Department of Physics, University of Oxford, Danilo Marchesini Tufts University, Claudia Urbina University of Western Australia, Cemile Marsan York University, Rhea-Silvia Remus Ludwig Maximillian Universitaet of Munich

We will find out.

This is important because massive quiescent galaxies at high-redshift have historically driven forward our understanding of galaxy formation and evolution. Numerous spectroscopic confirmations have shown that these galaxies do exist at z>3, however the measured number densities are still highly uncertain and depend on large photometrically selected samples. Massive quiescent galaxies at high-redshift evolve rapidly and so constraining hydrodynamical simulations with precise number densities is critical.

To address this, a recent spectroscopic campaign to target 24 photometrically pre-selected quiescent galaxy candidates (z>3, stellar mass>2E10 Msun selection) was undertaken with MOSFIRE/Keck in H+K. Here only 12 galaxies were spectroscopically confirmed, 3 of which were highly uncertain, leaving a possible 12 quiescent galaxies still unconfirmed - many with continuum detections and no emission lines.

Here we propose to observe the 15 uncertain or unconfirmed quiescent galaxy candidates with JWST NIRSpec PRISM, which will allow wide field-of-view observations and continuous 0.6-5μm spectral coverage to efficiently measure their spectra and produce highly complete and definitive number densities and ages. These galaxies are the fainter ones in the quiescent galaxy candidate sample but not necessarily the least massive, as the older age populations will be less luminous. Confirming these massive galaxies would pose significant challenges for galaxy formation and evolution theories.
JWST Cycle 1 Abstract Catalog

Proposal Category: GO
Scientific Category: Galaxies
ID: 02566
Program Title: Characterizing Stellar Mass Assembly and Physical Properties in the Brightest Galaxy in the Redshift>5 Universe

Principal Investigator: Gourav Khullar
PI Institution: University of Chicago

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We propose for spectroscopy and imaging of COOL J1241+2219, a recently discovered lensed galaxy at z~5.043 that at H_AB=20.5 is the brightest galaxy (at OIR wavelengths) known at z>=5. COOL J1241+2219 is 5x brighter than the prior record-holder at these redshifts, and as such it has become the target of extensive follow-up observations, both from space- and ground-based observatories. This galaxy is at a redshift that allows NIRSpec IFU observations that in two grating settings span the entire suite of classical diagnostic emission lines at R~1000. That spectroscopy, and complementary NIRCam imaging, will allow measurement of a host of properties in this galaxy, and due to lensing at spatial scales of ~100 pc! Specifically we will measure the morphology and internal structure, dynamics, metallicities, physical conditions of the nebular gas and powering hot stars, and the star formation history back into and through the epoch of reionization. We will do this both for the galaxy as a whole at exquisite signal levels, to connect this galaxy to broader extent knowledge of the z~5 universe, and patch-by-patch at ~100 pc scales. A key and defining aspect of these observations will be the measurement of "direct" metallicities, establishing a critical benchmark for many other expected JWST studies. This modest investment of time with an extraordinary observatory observing an extraordinary object will establish a key observational reference at an epoch immediately following reionization, where our detailed knowledge of galaxies is still remarkably limited.
The black hole (BH) mass function (MF) in the local universe - a fundamental measure of the origin and growth of BHs over Cosmic time - remains poorly constrained at intermediate masses. The very existence of BHs in this mass range is debated, but likely hosts include low-mass dwarf galaxies, for which the occupation fraction of BHs is an important ingredient for competing theories on supermassive BH (SMBH) formation. Observational challenges limit available avenues to search for BHs in dwarfs, but one under-utilized strategy is to infer the presence of central BHs by their dynamical influence on the cores of compact stellar systems (CSSs) including globular clusters, nuclear star clusters, ultra-compact dwarf galaxies (UCDs), and compact elliptical galaxies. CSSs have interconnected (often galactic) formation histories, and this technique has recently been successful in detecting SMBHs in several nearby UCDs, thereby proving their galactic origins as the remnant nuclei of former dwarf galaxies tidally stripped of their outer stellar sheaths. With the launch of JWST a systematic census of BHs in CSSs possible, as similar studies are prohibitively expensive using current ground or space-based facilities. To capitalize on JWST's capabilities we propose to use NIRSpec+IFU to obtain spatially-resolved stellar kinematics of 18 carefully selected CSSs crossing nearly four decades in mass, and located in a single cluster environment (Virgo). The R~2700 spectral datacubes will reveal dynamical fingerprints of BHs with masses \(-10^{5.5}\) Msun, providing enw insights into the occupation fraction of BHs in low-mass systems, and critical information on the origin of both CSSs and SMBHs.
To date, the atmospheres of young, cool, and low-mass exoplanets have remained a largely unexplored mystery to us. As the majority of these types of planets have transmission spectra with features too small to detect with Hubble/WFC3’s precision, we know very little about how these planets form and evolve. Much of what we do know from observations, we have had to extrapolate from hotter, older, or more massive exoplanets. But is this a valid assumption? Do cool and low-mass planets form and evolve under the same conditions, following similar pathways? Webb is poised to answer these questions over the next decade by observing the spectra of these cooler, less-massive worlds. With these observations we can finally integrate new planets spanning new parameters into our models, enabling us to test current planetary formation and evolution theories. To accomplish this, we are proposing to observe the transmission spectrum of Kepler-51d, a cool, young, low-mass super-puff planet. By capitalizing on Kepler-51d’s large scale height, we will characterize the chemical composition of its atmosphere and the structure of its haze layer, which was previously observed by Hubble/WFC3. In doing so, we will begin to quantitatively understand where Kepler-51d formed in its disk and what atmospheric evolution processes this young planet is currently undergoing as it moves towards its final quiescent state.
The Lucy spacecraft – to be launched at approximately the same time as JWST – will perform the first ever in situ exploration of the Jupiter Trojan asteroids. Trojans are the largest population of solar system bodies currently unvisited by spacecraft, and revealing their composition and formation history is the key to untangling disparate hypothesis for the early dynamical evolution of the entire solar system.

Understanding these enigmatic bodies requires not just the high spatial resolution imagery and spectroscopy that will be afforded by Lucy, but also the superb near- and mid-infrared spectroscopy of which JWST is uniquely capable. The high signal-to-noise, high spectral resolution, and extended wavelength coverage beyond the capabilities of Lucy will allow JWST to sensitively probe the organic, carbonate, and silicate components of the surfaces of the Trojans. Meanwhile, the Lucy spectra and images will place these observations into their geological and historical context, greatly extending the scientific utility of both the JWST observations and the Lucy visit. Together these observations will paint a rich picture of this population, allowing us to trace connections with other bodies studied remotely and in situ across the solar system.
The so-called ‘overlap’ region of the nearby merging Antennae galaxies provides a unique laboratory to study the formation of young globular clusters. While Hubble has already revealed some of these massive young clusters in the optical and near-infrared, the vast majority remain hidden behind large amounts of dust which reach extinction values as high as Av~30 mag. JWST now enables the characterization (ages/masses) of essentially ALL deeply buried young (<10 Myr), massive (>10,000 Msun) clusters in the dusty overlap region for the first time, using NIRCam & MIRI imaging. From the resulting complete catalog of young massive clusters (including optically selected ones from HST), we will determine the fraction of stars formed in clusters & construct and fit the initial cluster mass function. The results will be compared with predictions from hydrodynamic simulations which use a large range of prescriptions for star formation and stellar feedback in galaxy mergers. A comparison between the mass function of clusters and molecular clouds detected in available ALMA observations will yield estimates of the star cluster formation efficiency. Maps of 3.3 to 7.7 micron PAH emission will help diagnose grain sizes in this extreme star-forming environment. The strong IR emission from luminous infrared galaxies (LIRGs) usually comes from a combination of star formation and an accreting AGN; the Antennae present a unique case where the IR emission is driven only by star formation. This system therefore provides a critical bridge between star formation processes in normal (disk) galaxies, and the more intensely star-forming galaxies commonly found in the young and distant universe.
We propose a medium, early-release program to secure 8 transits of the Earth-sized exoplanets TRAPPIST-1 (T-1) b, c, g, and h using NIRSpec and NIRISS, that is, 2 transits of each of the planets b and c with NIRISS, and 2 transits of each of the planets g, and h with NIRSpec. We aim to 1) provide the community with the earliest possible data set for the atmospheric reconnaissance of all T-1 planets by complementing the GTO to prepare for a more ambitious legacy T-1 program, 2) characterize and assess the level of stellar contamination caused by the transit light source effect associated with unocculted spots, and 3) quantitatively compare the performance of NIRSpec and NIRISS, for relatively faint targets like T-1. Considering state-of-the-art atmospheric models of T-1 planets, the proposed observations should detect/rule out several baseline model atmospheres for all planets and may enable the detection of CO2 and H2O on T-1b and c and CO2 and O3 on T-1g and h, given some specific atmospheric compositions. The wavelength coverage of NIRISS and NIRSpec can determine the nature of the stellar contamination if present (cold/hot spots). We will also take advantage of NIRISS' higher spectral resolution (and non-saturation) to probe temperature-sensitive stellar lines to further quantify the nature and level of contamination. The two-instrument strategy will provide a balanced data set of the T-1 planets to assess the relative performance of both instruments in terms of non-linearity, intra-pixel sensitivity, and slit loss/finite subarray effects. No proprietary period is requested for this program, the bulk of which can be scheduled early in Cycle 1.
Tracing the build-up of metals over cosmic time is a key science goal of JWST, but the primary diagnostics of chemical abundances are indirect and currently without suitable calibrations at high redshifts. Various "strong line" metallicity indicators that work well in the local universe produce conflicting predictions at z~2-3 because they rely on intrinsic correlations among the physical conditions in galaxies' star-forming regions and their massive stars, both of which are significantly different in the early universe. This program uses NIRSpec to provide a new calibration sample of galaxy spectra to characterize these intrinsic correlations in situ at z=2. The proposed observations will enable "direct" electron-temperature-based measurements of gas-phase metallicities as well as independent estimates of the hardness of the stellar ionizing fields. In turn, these data will enable the re-calibration of strong-line metallicity estimators and improve the interpretation of photoionization models at high redshift. In contrast to other methods of calibrating these relationships, the [SII]6312+[OII]7320,30 method proposed here is efficient over a broad parameter space of galaxy properties, including at high metallicities where current methods disagree, and it is uniquely achievable using JWST. The proposed sample includes galaxies selected using multiple methods over a wide range in stellar mass to maximize the applicability of the resulting relations to diverse galaxies across cosmic time. The outcome of this proposal will be tools that can be used to determine chemical abundances for thousands of future objects observed by JWST from z=2 to the Epoch of Reionization at z>6.
What sets the radius of a planet? Even at a given mass and equilibrium temperature, gas giants have a broad spread in radius, and it is unclear under which circumstances thermal evolution; migrational and mass-loss history; or composition is the dominant controller of a planet’s radius. Studies of individual planet atmospheres can help. Recently, Fortney et al. (2020) showed that atmospheric CH4/H2O and CH4/CO2 abundance ratios are probes of interior temperatures of moderately-irradiated exoplanets (T eq~750K). This “CH4 thermometer” can be used to infer whether a hot interior is responsible for an inflated planet, and it can also measure vertical atmospheric mixing - which is currently unconstrained for most exoplanets. We propose to test these theories for the first time on the only two appropriate planetary twins available: WASP-107b and HATS-72b. They both have the same mass (0.12MJ), stellar type (K5/6), and equilibrium temperatures (750K), but HATS-72b’s radius is significantly smaller, making it twice as dense as WASP-107b. With only two transit observations of HATS-72b with NIRISS and NIRSpec, we can measure CH4, H2O, CO and CO2 abundances to 0.2 dex, which we would compare to GTO observations of WASP-107b, implying a colder interior. As HATS-72b is significantly older, it is expected to show stronger CH4 features and so comparing the CH4/H2O and CH4/CO abundance ratios between these two planets will give direct insight into their internal temperatures and the evolutionary history of exoplanets.
In recent years, HST measurements of the rest-frame UV luminosity function have provided a first census of reionization sources, and the efficacy of these sources as Lyman-alpha emitters (LAEs) has been used to constrain the global neutral fraction. Of particular interest are the recent discoveries of bright LAEs at \( z > 7 \). Empirical evidence suggests that these emitters are being found deep in the reionization epoch, when the IGM was still highly neutral. The observed intensity of Lyman-alpha emission and the occurrence of nearby galaxies has led some to speculate whether these sources reside in cosmological density peaks that were among the first to be reionized. With its enhanced sensitivity and spectroscopic capabilities, the JWST will soon open up an entirely new view of reionization-era galaxies and their environments. Relating the properties of sources to the reionization process around them is a chief goal of high-\( z \) galaxy observations. However, since the JWST cannot observe the ionization structure of the IGM directly, a key ingredient for this endeavor is a detailed theoretical understanding of how reionization-era galaxies shaped their cosmological environments and vice versa. The project proposed here aims to provide that understanding. Using an innovative suite of reionization simulations, we propose to study how the spectral properties and clustering of \( z > 7 \) galaxies are correlated with the structure of the earliest ionized bubbles. The proposed research would guide survey strategies and would help maximize the reionization science yield of JWST.
Proposal Category: GO
Scientific Category: Stellar Populations and the Interstellar Medium
ID: 02609
Program Title: Searching for the Alpha-Abundance Bimodality in the M31 Disk
Principal Investigator: David Nidever
PI Institution: Montana State University - Bozeman

Col Investigators:

The recent era of large, ground-based abundance surveys has unraveled the chemical structures of our Milky Way galaxy. The most striking abundance feature is the alpha-abundance bimodality. The low-alpha stars are younger (1-8 Gyr) while the high-alpha stars are older (8-12 Gyr) and have a thicker distribution. There are a number of different models that attempt to explain this chemical feature, but so far none have been strongly favored by the data. However, they do make different predictions about the prevalence of the alpha-bimodality in Milky Way-mass galaxies. Therefore, we propose to take NIRSpec MSA medium-resolution (R≈2700), high-S/N observations of ~130 red giant branch stars in the M31 disk with which we will measure precise metallicity and alpha-abundances (to ~0.03 dex) and search for an alpha-bimodality. These first precise elemental abundances in the M31 disk will double our sample of MW-mass galaxies with which to compare and constrain the models. This will allow us to take a big step forward in our understanding of the most important chemical process at work in our galaxy. In addition, we will use the abundance information, in combination with accurate star formation histories from the PHAT survey, to probe the chemical evolution of the M31 disk in more detail using one-zone chemical evolution models that will allow us to constrain the star formation efficiency, inflow and outflow rates, and initial mass function. This pilot program will demonstrate the utility of NIRSpec for obtaining individual elemental abundances to explore the chemical enrichment of stellar populations lying well beyond the Milky Way in the Local Group.
With its sensitivity in the near- and mid-infrared, the James Webb Space Telescope (JWST) will further push the limits of high-contrast imaging (HCl) by probing the population of young exoplanets at wide separations down to Saturn masses. Because stellar light residuals dominate over the background in regions up to 2" from the star, some crucial scientific discoveries may be missed, preventing their follow-up during the short life-span of this exceptional observatory. The current recommended strategy for JWST coronographic imaging involves contemporaneous calibration exposures of a reference star. Those observations, accounting at least for half the time spent observing the science target or more, are subject to wavefront drifts that prevent the subtraction of stellar light down to the photon noise level. There is a high need for an alternative strategy that would leverage our knowledge of the observatory to further improve the calibration of stellar light residuals while avoiding the need for time-consuming calibration exposures. The proposed observations will be used to test and validate a model-based phase retrieval algorithm that estimates the instrumental aberrations directly from HCl observations. Data from wavefront sensing operations will help to constrain the phase retrieval. Angular differential strategy and dual-band imaging will be used to disentangle the astrophysical signal from the residual starlight. Calibration data will be requested in the form of non-coronagraphic and coronagraphic NIRCam images just before and after WFS. The findings will be used to draw recommendations for coronagraphic imaging observing strategies in the subsequent JWST cycles.
Observations of the magnetar 4U 0142+61 with the Spitzer space telescope have shown a broad infrared excess with a possible silicate spectral feature at 9.7 micron. This result was interpreted as emission from a passive disk surrounding the energetic isolated neutron star. Such disks, predicted by supernova dynamic models, have been long sought after because they can elucidate details of neutron star formation and evolution. Unfortunately, the Spitzer spectrum was of low quality, thus an infrared flux contribution from the neutron star’s magnetosphere remains a possibility, leaving the origin of the magnetar’s infrared-optical spectrum uncertain. JWST will enable a thorough investigation and clarification of the nature of 4U0142+61’s infrared emission. Taking advantage of the NIRCam subarray time-series mode, we also propose to investigate the pulsations of emission from this slowly spinning neutron star to quantify the contribution of the magnetosphere and separate the magnetospheric emission from the disk emission.
Proposal Category: GO
Scientific Category: Stellar Physics and Stellar Types
ID: 02640
Program Title: A Census to the Bottom of the IMF in Westerlund 2: Atmospheres, Disks, Accretion, and Demographics
Principal Investigator: William Best
PI Institution: University of Texas at Austin
CoInvestigators: Katelyn Allers Bucknell University, Beth Biller University of Edinburgh, Institute for Astronomy, Brendan Bowler University of Texas at Austin, Trent Dupuy University of Edinburgh, Institute for Astronomy, Clemente Fontanie University of Bern, Kaitlin Kratter University of Arizona, Adam Kraus University of Texas at Austin, Jessica Lu University of California - Berkeley, Caroline Morley University of Texas at Austin, Stella Offner Department of Astronomy, University of Texas, Megan Reiter United Kingdom Astronomy Technology Centre, Aaron Rizzuto University of Texas at Austin, Yifan Zhou University of Texas at Austin

Young brown dwarfs (BDs) and planetary-mass objects (PMOs) offer powerful tests of the universality of the IMF, the frequency and timescale of planet formation, and the typical atmospheric properties (and range of their variations) for analogs of directly-imaged and transiting planets, all at extremes (protostellar mass, disk mass, insolation) where models are most strained. Most known PMOs are in nearby sparse populations (including GTO targets with exquisite data), but these regions are small (with few PMOs) and spread out (limiting multiplexing). Given JWST's superb sensitivity, there is not such a premium on close and bright; value instead comes from source density. Distant, dense clusters offer more and denser targets, and HST has revealed them just in time for carefully optimized JWST follow-up.

We propose a highly multiplexed NIRSpec+NIRCam pilot program for young BDs and PMOs, targeting 1 pointing in the young (1-2 Myr), massive (30,000 members), and dense (R-8 arcmin) Westerlund 2 cluster. We propose NIRSpec/MOS spectra of known young members (prism for 94 faint BDs and PMOs and 37 brighter BDs, plus grism for 27) to measure Teff, gravity, accretion from emission lines, and disks from IR excess. We also propose parallel NIRCam imaging in 12 filters (for SEDs, water bands indicating low Teff, and emission lines) to seek the very bottom of the IMF (2 Mjup) and measure Teff, accretion, and disks. In summary, our program will deliver a large and robust census of the lowest-mass objects, providing a new view of the IMF, disks, planet formation, and the atmospheres of direct analogs to the direct-imaged and transiting planets that drive much of JWST's key science.
The search for dual supermassive black holes is of immense interest in modern astrophysics. Following a merger of two galaxies, the two central supermassive black holes evolve into a bound binary and further inspiral until they eventually coalesce into a single merger product. If black holes are actively accreting during the inspiral, such objects can be observed as a dual or binary quasar. Gaia observations have enabled a novel technique to search for such dual quasars at previously unreachable sub-kpc scales, based on the small motions of the light centroid as the two sources vary stochastically. We propose to study two kpc-scale dual quasars identified with this method and confirmed with follow-up observations at z=2-3, the peak epoch of galaxy formation. Dual quasars at this epoch are not well characterized, especially due limited wavelength coverage of key spectral features and stringent spatial resolution requirements. The unprecedented NIR sensitivity, spatial resolution, and spectral coverage of JWST will enable us to study the gas dynamics in dual quasars for the first time at these redshifts. We propose to use the IFU capabilities of NIRSpec and MIRI to study the impact of these dual quasars on their hosts and to probe the quasar fueling mechanisms, host galaxy merger signatures, host stellar continuum, and merger induced star formation.
We propose restframe UV and optical spectroscopy to confirm redshifts and measure star-formation rates, stellar masses, and dust extinction for the five most luminous galaxies at 9<z<10 over two square degrees of the COSMOS survey. The unique combination of a wide-field near-infrared imaging coupled with new ultra-deep optical and infrared data makes this the most secure sample of 9<z<10 galaxy candidates currently available. However, these objects are too rare to be found by very deep, but smaller surveys with JWST, and the serendipitous discovery of even one such galaxy outside of COSMOS is unlikely from the entirety of planned GTO and ERS programs. These massive, luminous galaxies, seen only 500 million years after the Big Bang, are ideal tracers of the primordial dark matter structures from which they formed and grew. However, their mere existence at these early times challenges the current paradigm of early galaxy formation and evolution. Thus, it is essential to confirm their high redshift nature and reveal the means by which these remarkable cosmic beasts so rapidly built up their stellar mass.
NGC 602 is an extraordinarily interesting young star cluster, because it is located in a very low-density, low-metallicity region in the SMC Bridge, but still has formed a remarkable content of stars (10^3 Solar masses), and hosts multiple OB stars, similar to Orion. Spitzer observations have revealed a number of Young Stellar Objects (YSOs) embedded in the surrounding gas and dust ridges, but the Spitzer spatial resolution did not allow for a direct comparison with existing Hubble images. We are proposing to exploit NIRCam and MIRI’s exquisite sensitivity and resolution to a) conduct a census of the YSOs in the cluster region, b) establish if the central OB stars are driving star formation (SF) into the surrounding HII region, and c) probe how the OB winds influence the disk-bearing population of pre-main-sequence (PMS) stars found by Hubble.

Only the unprecedented sensitivity and resolution of Webb will allow us, for the first time, to observe ALL YSOs down to 1 Solar mass and to characterize protoplanetary disks of PMS stars down to the hydrogen-burning limit, in a cluster outside the Milky Way (MW).

We will investigate how efficiently stars continue to form in the surrounding gas and dust cloud, which might lead to an extended period of SF even after the main cluster has started to disperse. We will study how protoplanetary disks around low-mass stars evolve in close proximity to the OB stars in a low-metallicity environment, where winds are less powerful than in our own Galaxy. By comparing the results with similar clusters in the MW, we will add crucial information to the current debate on how star and cluster formation is affected by local environmental conditions.
Core-collapse supernovae (CCSNe) have long been considered as possible sources of dust in the Universe. Searches with Spitzer and other telescopes have historically come up with dust masses 2-3 orders of magnitude too small compared to theoretical predictions. These observations, however, have generally been limited to early epochs, and in many cases, just the warmer dust. Over the past decade, however, new observations suggest that continuous dust formation builds over decades. As new dust forms, the old dust cools so that massive reservoirs of colder dust are hidden, except at longer wavelengths. Although SN 1987A showed a clear trend in dust growth from $10^{-3}$ to 1.0 solar masses over a 30 year period, no other SNe have measured dust masses later than 5 years post-explosion. The limited data is mostly due to the fact that no instrument has been sensitive to colder (~100-200 K) dust in extragalactic SNe (beyond SN 1987A). Here we propose JWST MIR Imaging of five of the most dusty, nearby, extragalactic SNe Type IIP that will be more than 5 years old by the time JWST observations begin. Our proposed data will result in a spectral energy distribution of the dust in each SN, which we will use to quantify the mass of cooler dust hidden at longer wavelengths and measure its characteristics. Taken all together, the data points will correspond to a variety of ages that will fill in the missing data of dust growth in SNe.
Aerosols control the energy budget of an atmosphere and how much light is reflected, absorbed, and re-radiated. Aerosols in exoplanet atmospheres are commonly defined as either clouds (formed via condensation) or hazes (formed via photochemical reactions). The effect of aerosols as scattering in the UV-optical and muting of gas phase abundances in the near-IR has been observed in transmission spectra from giant hot Jupiters down to sub-Neptunes. However, aerosols are not all bad news for exoplanet spectra. The composition of aerosols directly measured in the IR, as condensate clouds or photochemical haze, will inform the temperature and pressure structure of the atmosphere. Without direct measurements of the aerosol composition, particle size, and abundance, we cannot fully account for the gas phase composition, the thermal structure, or the dynamical mixing in giant exoplanet atmospheres.

We will measure the first direct evidence of aerosols in the atmosphere of an exoplanet by observing the vibrational-mode absorption from sub-micron sized particles in the atmosphere of HD 209458b with MIRI LRS. With these observations, we will be able to constrain the particle size of the aerosols to less than an order of magnitude. This will enable us to constrain the magnitude of dynamical mixing in the atmosphere needed to produce such particle sizes, which in turn informs the role of mixing in the gas phase chemistry. In just a single transit, these high precision observations will not only distinguish between aerosols composed of cloud condensates and organic hazes, but also examine the role of aerosols in the radiative transfer, dynamics, and chemistry of exoplanet atmospheres.
Galaxy clusters are the most massive gravitationally bound structures in the Universe and they play a key role in our understanding of structure formation and galaxy evolution. The particular conditions of these high density environments can have a significant effect on the evolution of galaxies. Previous studies have reported systematic differences in SFR, age and mass between field galaxies and galaxies in large clusters at z<2.5. However, we know little about how overdense environments affect the evolution of galaxies at z > 3.

We propose to use 15 h of NIRSpec and NIRCam parallel observations to measure optical nebular line emission properties for a well-defined sample of proto-cluster galaxies at z=5.2. Our target sample contains 11 spectroscopically confirmed members of the proto-cluster and 15 new candidates with accurate photometric redshifts, as well as 66 other field galaxies at similar redshifts, in order to: 1) use emission line diagnostics and stellar population modeling to directly compare properties of galaxies in high- and lower-density environments for the first time at this early cosmic epoch; 2) substantially increase the number of confirmed proto-cluster members, allowing a detailed characterization of the dynamical state of the overdensity, the identification of internal sub-structures through the analysis of the velocity dispersion, and application of cluster evolution formalism to trace the expected evolution of this large proto-cluster with redshift, and its eventual end as a Coma-like cluster at z=0; and 3) compare the Ly-alpha escape fraction for z~5 galaxies in and out of the proto-cluster environment.
The detection of PAH emission in galaxy halos or superwinds provides valuable insight into the destruction and survival of PAHs in hostile environments. The archetypal starburst, superwind galaxy M82 is an ideal laboratory for exploring these processes, not only because of the widespread detection of PAH emission all around the galaxy, but also because of the puzzling spatial variations of the PAH spectral profiles. More specifically, AKARI/IRC low-resolution observations have shown that in the plane of M82 the 3.4 micron aliphatic C--H feature is much weaker than the 3.3 micron aromatic C--H feature; in contrast, in the superwind the 3.4 micron feature supercedes the 3.3 micron feature. This is puzzling because in the harsh superwind environment PAHs would be easily stripped off any aliphatic sidegroups and not expected to show strong aliphatic emission. Also, if PAHs in the superwind are indeed highly aliphatic as suggested by the strong 3.4 micron emission, it is puzzling why the 6.85 and 7.25 micron aliphatic C--H deformation bands are not seen in the Spitzer/IRS spectra of M82.

We propose to map the PAH emission bands at 3--5 micron on a number of representative regions along the M82 superwind structures with the NIRSpec Multi-Object Spectroscopy at a spectral resolution R~1000. Combined with the previous Spitzer/IRS spectral mapping of this galaxy at 5--35 micron, we will be able to explore the PAH size and chemical structural (i.e., aromatic vs. aliphatic) properties and their spatial variations in M82 and gain insight into their origin, destruction and survival.
Proposal Category: AR
Scientific Category: Galaxies
ID: 02687
Program Title: Leveraging Early Public JWST Data to Measure Luminosity Functions and Rest-UV Slopes from 6<z<12
Principal Investigator: Micaela Bagley
PI Institution: University of Texas at Austin

Steven Finkelstein University of Texas at Austin, Casey Papovich Texas A & M University, Norbert Pirzkal Space Telescope Science Institute, Jennifer Lotz Gemini Observatory, Northern Operations, Harry Ferguson Space Telescope Science Institute, Rachel Somerville Rutgers University, Nimish Hathi Space Telescope Science Institute, Marco Castellano INAF, Osservatorio Astronomico di Roma, Stephen Wilkins University of Sussex, Romeel Dave University of Edinburgh, Institute for Astronomy, Christopher Conselice University of Nottingham, Denis Burgarella Laboratoire d’Astrophysique de Marseille, Anton Koekemoer Space Telescope Science Institute, Caitlin Casey University of Texas at Austin, Benne Holwerda University of Louisville Research Foundation, Inc., Rachana Bhatawdekar European Space Agency - ESTEC, Peter Behroozi University of Arizona, L. Y. Aaron Yung NASA Goddard Space Flight Center, Veronique Buat Laboratoire d’Astrophysique de Marseille, Ambra Nanni NCBJ, Taylor Hutchison Texas A & M University, Rebecca Larson University of Texas at Austin

The evolution of the rest-frame ultraviolet (UV) luminosity function encodes information on the key physical properties regulating galaxy evolution. While theoretical models, invoking a variety of sub-grid models, are able to match observations at z < 8, their predictions have significant scatter at higher redshifts. This is understandable at z > 9, Hubble only probes galaxies with a single imaging filter, so there is a variety of tension between observational studies. This will change with Webb; Deep near-infrared imaging planned early in Cycle 1 will probe 1-Sum, allowing the selection of large samples of robust z~10 galaxies. We propose for archival funding to analyze the data from four publicly available datasets (two Early Release Science programs, and two Guaranteed Time Observer programs with public releases). We will analyze these data in a systematic way to select robust samples of galaxies in this epoch, to 1) measure the shape of the bright end of the rest-UV luminosity function, constraining models of star-formation efficiencies, and 2) measure robust rest-UV colors, placing limits on the chemical enrichment in early galaxies. Doing these analyses early in the Webb mission will allow our first glimpse into the physical processes dominating galaxy evolution in the first 500 Myr, setting the stage for future Cycle 2 programs to push farther into the early universe.
Precise masses of white dwarfs (WDs) are needed to understand the astrophysics of this final stage of evolution for the majority of stars. However, there are surprisingly few direct mass measurements for WDs, almost all of them in binaries. A nearby single WD, L 845-70, will pass in front of a background star in 2024, with an impact parameter of only 185 mas. As it passes by, the WD will relativistically deflect the background star’s position, providing a rare opportunity to directly measure the WD’s mass. The deflection depends only on the known distances and positions of the stars, and on the mass of the WD. Thus astrometry offers a direct method to measure the mass of the WD to high accuracy (~2.5%).

High-precision astrometric microlensing was recently used with HST to measure the mass of the WD Stein 2051B—the first application of this technique outside the solar system. We propose JWST/NIRCam imaging to measure the mass of L 845-70. JWST has a considerably higher figure of merit (about a factor of 4) for this project compared to HST because (1) JWST offers a higher spatial resolution, and (2) the brightness contrast between the lens and the source in the near-IR is much more favorable than in the optical. This makes it possible to image the source, lens, and reference stars in the same exposures, rather than compromising the precision due to the short/long sequence needed with HST. Relativistic astrometric microlensing is the only available model-independent method for determining the mass of a single WD. Our measurement will add to the small number of accurate direct mass determinations for WDs—and will be only the second such measurement for an isolated WD.
COSMOS J100043.1+020637.2 (or CID-42) is a galaxy with exceptional properties: two optical nuclei separated by ~0.5", a long tidal tail, X-ray emission from only one optical source, and a broad Hβ emission-line centered at 1300 km/s from the systemic velocity. These properties make CID-42 the best candidate gravitational wave (GW) recoiling supermassive black hole (SMBH) to date, but other scenarios, such as an inspiraling active galactic nucleus (AGN) pair, accretion disk kinematics, or a gravitational slingshot recoil resulting from a triple-SMBH encounter cannot be excluded. With spatially resolved JWST NIRSpec integral-field unit (IFU) spectroscopy, it is now possible to definitively determine whether this galaxy hosts a GW recoiling SMBH by mapping the 2D kinematics of the stars and the broad and narrow emission lines of ionized gas. We will be able to determine in a straightforward way three main kinematic properties of GW recoiling SMBHs: (i) the kinematically-offset broad emission lines should be spatially coincident with the spatially-offset AGN, (ii) the kinematic center of the galaxy should be spatially coincident with the central stellar cusp left behind by the recoiling SMBH, and (iii) the velocities of the narrow emission lines should be close to the systemic velocity of the galaxy at all spatial positions in the field-of-view and not close to the kick velocity of the merged SMBH. The proposed observations will have a tremendous impact on our knowledge of SMBH mergers and the associated emission of GWs. In fact, with a small investment of ~5 hours, this experiment could confirm the existence of GWs from SMBH mergers.
Proposal Category: GO
Scientific Category: Exoplanets and Exoplanet Formation
ID: 02708
Program Title: The Thermal Emission Spectrum of the Closest M Dwarf Transiting Rocky Planet
Principal Investigator: Zach Berta-Thompson
PI Institution: University of Colorado at Boulder
CoInvestigators
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The rocky planets in our Solar System each have their own complicated stories to tell, and we have decades of data observing them up close. Yet, looking at the innermost worlds of Mercury and Venus, we still don't have complete answers to simple questions. How much bigger would Mercury need to be, in order for it to have retained an atmosphere? How much more closely to the Sun could Venus orbit, without its thick atmosphere eroding into space? Observations of exoplanets can help answer these questions. Both thanks to exoplanet discovery efforts that have provided worlds starting to resemble those our Solar System and thanks to Webb for providing the long-wavelength sensitivity needed to observe these cool planets, we can start to directly observe planets that resemble our own. Here, we propose to use MIRI/LRS to observe the emission spectrum of the exoplanet LTT1445Ab and use its dayside temperature to determine whether or not it has an atmosphere. At mere 6.9pc away, the LTT1445 system is the closest M dwarf known to host a transiting planet, and determining whether or not it has an atmosphere provides crucial context for the decade of exoplanetary science ahead. This work would provide valuable insight to atmospheric escape from rocky planets both within the Solar System and beyond.
One of the major developments in the past year has been the first detection of H2O in the atmosphere of the mini-Neptune K2-18b orbiting in the habitable-zone of its host star, with an equilibrium temperature of ~300 K. The observations revealed an H2-rich atmosphere with strong absorption from H2O, but also a surprising paucity of methane (CH4) and ammonia (NH3). Given the low temperatures in the atmosphere, CH4 and NH3 are expected to be the prominent carriers of carbon and nitrogen in a H2-rich atmosphere. The non-detections of CH4 and NH3, therefore, suggest strong thermochemical disequilibrium in the atmosphere of K2-18b, similar to the "missing methane problem" in other low-mass planets which is one of the longest-standing conundrums in exoplanetary atmospheres. Given its low temperature and high observability, K2-18b serves as the perfect test case for investigating this problem and for understanding physical and chemical processes in exoplanetary atmospheres in the temperate regime. We propose to conduct unprecedented observations of K2-18b to resolve this long-standing puzzle. Using JWST broadband transmission spectroscopy with NIRISS, NIRSpec and MIRI, our observations aim to make the first detections of CH4 and NH3 in K2-18b and place unprecedented constraints on chemical disequilibrium in its atmosphere.