Poster Presenters

Assembly of Galaxies (Intergalactic & circumgalactic medium, AGNs, galaxy formation & evolution)

Spatially resolved stellar populations of lensed galaxies at $0.5<z<6.0$ as revealed by JWST Imaging
Abdurro'uf

To understand how galaxies evolve over cosmic time requires knowledge of not only integrated properties but also spatially resolved properties within galaxies. The high spatial resolution and deep imaging observations, particularly with the space telescopes, such as the HST and now with the JWST, opens up avenues for the studies of spatially resolved properties of a large number of galaxies over a wide range of redshifts. The SED fitting method for extracting the physical properties from photometric data is now well established with the advancements in the statistical techniques. In this poster, I will present our study of the spatially resolved properties (on kpc scales) of over 700 galaxies at $0.5<z<6.0$ in the WHL0137 and MACS0647 cluster fields that are observed with the JWST as part of the GO2282 and GO1433 programs. Many of the galaxies are magnified and stretched by the gravitational lensing effect of the clusters, making it easier to be analyzed with the spatially resolved SED fitting. Our novel method utilizing piXedfit is capable of analyzing spatially resolved SEDs of galaxies, enabling a comprehensive analysis of the spatially resolved properties of galaxies at high redshifts. This approach offers a good alternative to the more expensive IFU observations for dissecting the properties of a statistically large number of galaxies over a wide redshift range.

When did massive galaxies begin to form? Expectations from Illustris using simulated CEERS/JWST + CANDELS/HST imaging data

Ángela García-Argumánez, Pablo G. Pérez González, Armando Gil de Paz, and the CEERS collaboration

We use the Illustris-1 simulation to explore the capabilities of the Hubble and James Webb Space Telescope data to analyze the stellar populations in high-redshift galaxies, taking advantage of the combined depth, spatial resolution, and wavelength coverage. For that purpose, we use simulated broad-band ACS, WFC3 and NIRCam data and 2-dimensional stellar population synthesis (2D-SPS) to derive the integrated star formation history (SFH) of massive ($M_* > 10^{10} M_\odot$) simulated galaxies at $1 < z < 4$ that evolve into a local $M_* > 10^{11} M_\odot$ galaxy. In particular, we explore the potential of HST and JWST datasets reaching a depth similar to those of the CANDELS and ongoing CEERS observations, respectively, and concentrate on determining the capabilities of this dataset for characterizing the first episodes in the SFH of local $M_* > 10^{11} M_\odot$ galaxies by studying their progenitors at $z > 1$. The 2D-SPS method presented in this paper has been calibrated to robustly recover the cosmic times when the first star formation episodes occurred in massive galaxies, i.e., the first stages in their integrated SFHs. In particular, we discuss the times when the first 1% to 50% of their total stellar mass formed in the simulation. We demonstrate that we can recover these ages with typical median systematic offset of less than 5% and scatter around 20%-30%. According to our measurements on Illustris data, we are able to recover that local $M_* > 10^{11} M_\odot$ galaxies would have started their formation by z=16, forming the first 5% of their stellar mass present at z ~ 1 by z=4.5, 10% by z=3.7, and 25% by z=2.7.

Metallicity gradient evolution in FOGGIE simulations

Ayan Acharyya, FOGGIE

Gas-phase metallicity gradients of galaxies are a crucial ingredient for understanding the chemical evolution of galaxies. Observations only capture a single snapshot of a galaxy's evolution, necessitating the need for time-domain simulations to interpret said evolution. Using the FOGGIE simulations we demonstrate that a high cadence (~few Myr) is indispensable for accurately tracking the metallicity gradient evolution, particularly at high-redshift (z). Most other simulations report a smooth evolution in gradient owing to insufficient cadence. FOGGIE galaxies spend ~50-80% (~10-20%) of their time up to z=2 (z=0) outside the typical observational uncertainty away from the temporally smooth (~50 Myr) behaviour -- which a low cadence study would be unable to capture. Additionally, we present a novel, non-parametric method of quantifying the metallicity distribution that is free from geometric assumptions as well as less susceptible to systematic uncertainties from the lens-model reconstruction employed in several high-z observations. We investigate how efficiently this new quantification responds to stimuli such as star-formation, mergers and outflows. We thus pave the way for interpreting the new and upcoming JWST observations of high-z metallicity gradients with unprecedented sensitivity.

Intergalactic Star-Forming Regions in Stephan's Quintet: A JWST Perspective
Beverly J. Smith, Mark Giroux, Xavier Hurley

We present preliminary results from JWST imaging of intergalactic star-forming regions within Stephan's Quintet. We investigate how the infrared spectral energy distributions of these regions vary with other properties of the regions, and discuss future prospects.

FOR DISCOVERY OF PRIMEVAL GALAXIES
Brigitte ROCCA-VOLMERANGE

While the main properties (mass, formation redshift, star formation efficiency,...) of primeval galaxies are still highly debated, one essential parameter to follow is the metallicity evolution. With respect of this parameter, the code PEGASE.3 (Fioc & Rocca-Volmerange, 2019ab) predicts the emissions of stellar populations (continua and lines) and their exchanges with ISM (infall, outflow) from star formation and evolution to CoreCollapse Supernovae and their ejecta as a function of galaxy age. The main results for JWST are the evolution with age of the spectral energy distributions (SED, magnitudes, colors) on the largest wavelength domain (farUV-Optical-farIR-submm) taking into account the coherent absorption/emission by grains by MonteCarlo simulations. The last results are on submission.

A MIRI view of normal star-forming galaxies at z < 2.0: the new window opened by the detection of PAH features

Danial Langeroodi, Jens Hjorth, Steven Gillman

Prior to the JWST, mid-infrared studies of star-forming galaxies at redshifts higher than 0.2 have been mostly limited to the Spitzer observations of (Ultra) Luminous Infrared Galaxies, which are not representative of typical star-forming galaxies. The MIRI instrument onboard the JWST for the first time enables mid-infrared observations of fainter "normal" star-forming galaxies at 0.2 < z < 2, where and when the bulk of cosmic star-formation takes place. Constructing large and representative samples of such galaxies, observed in mid-infrared wavelengths, is instrumental for advancing our understanding of the evolution of cosmic star-formation. The unique mid-infrared spectra of star-forming galaxies provide a so far-unexplored avenue for constructing such samples. The mid-infrared spectra of these galaxies are dominated by broad Polycyclic Aromatic Hydrocarbon (PAH) emission features, most notably at 3.3, 6.2, 7.7, 8.6, and 11.3 micron. As PAH features get redshifted they pass through the MIRI filters, resulting in substantial redshift-dependent color variations in the broad-band photometry of star-forming galaxies; this can be used to accurately determine their redshifts. Moreover, since the PAH features are less pronounced in AGNs and entirely absent in quenched galaxies, these PAH-dominated mid-infrared colors can be used to distinguish star-forming galaxies from early-type galaxies and AGNs. In this talk, we provide the first demonstration of these techniques, in identifying the star-forming galaxies and estimating their redshifts in the MIRI Early Release Observations of the field towards SMACS J0723 as well as the MIRI European Consortium GTO observations of the field towards SPT0311-58.

Are disk galaxies the dominant morphology of the z > 3 Universe?

Jesús Vega Ferrero, Marc Huertas-Company, Luca Costantin, and Pablo Pérez González

With the first CEERS data release, the JWST is already unveiling the rest-frame morphological properties of galaxies at z > 3. Recent studies based on CEERS data indicate that galaxies at z > 3 are not dominated by irregular (or peculiar) morphologies, but by disk galaxies up to z > 8, at least from a visual perspective.

We propose an alternative approach to explore the morphological diversity of galaxies at z > 3 from a data-driven perspective based on self-supervised deep learning. We show that our proposed classification scheme is robust to noise and correlates well with kinematic properties inferred from the TNG50 cosmological simulation.

We apply our methodology on a mass complete sample at z > 3 from the first CEERS data release. Our preliminary results indicate that a significant fraction of visually classified disk galaxies do not fully share the expected properties of disk galaxies at lower redshifts (i.e., large angular momenta, large fraction of mass in a disk component, flatness, etc.). If confirmed, our results would point out to smaller fractions of typical disk galaxies at z > 3 than those obtained from a purely visual classification scheme.

Observability of SMBHs in the early Universe with JWST

Junehyoung Jeon, Volker Bromm, and Steven Finkelstein

Objects such as supermassive black holes (SMBHs) and high-mass X-ray binaries (HMXBs) produced X-ray feedback in the pre-reionization Universe and possibly acted as a major source of reionization and the thermal evolution of the intergalactic medium. X-ray sources at high redshift have remained largely unobservable so far. However, with deep JWST observations, we may be able to observe the first seeds of SMBHs at high redshift. To test such predictions, we create an analytic model of overall SMBH growth by considering X-ray feedback from SMBH accretion. The model is derived from the energy balance between thermal feedback and the confining gravitational potential of the halo and is calibrated with the Press-Schechter halo mass function. We test our model and parameter choices against various observational constraints, verifying that our model parameters do not violate any constraints while providing maximal X-ray feedback prior to reionization. We then run a cosmological box simulation with the GIZMO code and follow the growth of SMBH seeds with initial masses chosen to be in agreement with our model. The predicted flux from the SMBH growth across redshifts indicates that while the more common SMBH seeds from stellar remnants may not be observable with JWST, the more massive direct collapse black hole seeds should be within reach of JWST.

The Sparkler: high redshift globular cluster candidates resolved with JWST

Kartheik Iyer Work with Lamiya Mowla and the CANUCS collaboration

Observations of the SMACS 0723 cluster have showcased JWST's incredible capabilities in characterizing the properties of distant galaxy populations. The combination of NIRCam's high angular resolution and gravitational lensing by the foreground galaxy cluster make it possible to resolve structure in distant galaxies beyond what was possible in previous surveys. We focus on one particular multiply lensed galaxy at z=1.38 that shows a collection of compact red objects around it. Analyzing these objects in detail, we find them to be red, quiescent objects that are candidates for globular clusters that formed at epochs of z>7. This discovery opens up the possibility of studying the growth of galaxies and their parent halos through their globular cluster populations at higher redshifts than thought possible before JWST, leading to tighter constraints on the formation ages and mechanisms of globular clusters. The CANUCS Cycle 1 GTO program (http://canucs-jwst.com/), which will look at five strong-lensing cluster fields with NIRISS, NIRCam & NIRSpec, will extend this dataset and open up the possibility of finding other galaxies with similar characteristics.

Purported Isolated Globular Clusters in the Early Universe are Compact Star-Forming Galaxies

Man Cheung Alex Li

Dozens of lensed Lyα emitters (LAEs) of redshift > 3 have been reported by the Deep MUSE survey towards the massive cluster MACSJ0416. The Lyα emission in these high-redshift LAEs, which are often associated with compact sources in the HST images, are thought to trace outflows from isolated globular clusters in the early Universe. Here we select three lensed LAEs of high magnification (μ > 10) and large tangential angular size (θt > 10'') in MACSJ0416. We study their spectral properties from the Deep MUSE data and intrinsic morphology using the forward lensing approach based on our robust, self-consistent lens model constructed with 182 lens images as constraints. Detailed spectral analysis and source modeling show that these LAEs consist in compact star forming regions of size from ~0.04 kpc to ~1 kpc embedded in elongated Lyα halos of a few kpcs in radius. In particular, we discover one of these LAEs has an outflow of strongly preferred direction as indicated by its highly elongated appearance (e ~ 0.7) in the source plane. Further rigorous modeling manifests the bipolar intrinsic morphology of uniform surface brightness of this particular LAE. Such bipolar morphology represents a collimated outflow which can be driven by star formation in a compact disk galaxy but not an isolated globular cluster. The intrinsic morphology of the other two LAEs from our forward modeling is also consistent with outflows from compact star forming galaxies.

Multiphase gas kinematics traced by NIRSpec IFU observations of NGC7469

Marina Bianchin, Vivian U, and GOALS team

Active supermassive black holes can influence the fate of their host galaxies. Gas outflows, frequently triggered by the accretion disk radiation pressure, can disturb the gas kinematics at various galactic scales. We analyse the NIRSpec IFU data of the active galaxy NGC7469: a luminous infrared galaxy hosting a Seyfert nucleus and a prominent starforming ring. The spectra show prominent emission lines from the ro-vibrational molecular hydrogen transitions which mostly trace the gas at the inner ISM region. The molecular gas mostly displays rotation at a similar amplitude and direction as the ionised gas, traced by hydrogen recombination lines. Enhanced velocity dispersion at the central 300pc of the molecular hydrogen line is indicative of perturbed gas that may be associated with an AGN-driven outflow. We also identify extended emission from the coronal line [Ca VII] at 2.45 um. We investigate in detail the spatially resolved kinematics of the molecular, ionised as coronal gas components, as well as the mechanisms behind the H2 excitation using line ratio diagrams.

Deconvolution of GATOS JWST/MIRI AGN Images

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The stable image quality of the James Webb Space Telescope (JWST) permits deconvolution techniques to be pursued in a way unavailable to ground-based observations. In this poster, we present an assessment of the optimum deconvolution strategy using (1) MIRISim to simulate JWST's complex point spread function (PSF) applied to a toy model of an active galactic nucleus (AGN, considered a point source in toy model), and (2) our multi-band JWST/MIRI images of Seyfert AGN. Different deconvolution techniques employed include Richardson-Lucy, Adaptive Image Deconvolution Algorithm, multiscale Maximum Entropy method, Wiener-Hunt, and newly updated Kraken Multi-Frame Blind Deconvolution. Our Richardson-Lucy deconvolution shows a FWHM improvement of up to ~44%, at the longest wavebands, while maintaining flux integrity. The resultant FWHM is equivalent to a telescope of ~12.2 m diameter. Our work aims to identify the best deconvolution technique to achieve a spatial resolution limit below the diffraction limit of the JWST while preserving low surface brightness emission within the complex JWST PSF. We hope this work will be informative for the JWST community.

A Galaxy and Intracluster Light Distribution Model of the First JWST Lensing Cluster, SMACS0723

Nicholas Martis and CANUCS

I present a cluster galaxy and intracluster light distribution model of the first JWST lensing cluster, SMACS0723, that has been made available to the community. We also provide subtracted images utilizing these models and custom background estimation, allowing the detection of faint sources behind the cluster. We demonstrate the reliability and usefulness of this model by performing an analysis of the point sources in the field, many of which can only be detected after the light model subtraction. After isolating objects associated with the cluster, we study their spatial distribution with respect to our light model. We calculate a luminosity function for these objects, with a full accounting for completeness effects. Finally, we perform spectral energy distribution modeling using a combination of NIRCAM, NIRISS, and archival HST photometry to investigate the identity of these objects, considering the possibilities of globular clusters and compact dwarf galaxies. This study serves as a precursor to the analysis that will be performed by the CANUCS (CANadian Unbiased Cluster Survey) team with a set of five lensing clusters.

Constraining the Star Formation Timescales and Histories of High-redshift Massive Quiescent Galaxies with JADES

Nina Bonaventura and JADES

Since the discovery of a significant population of massive quiescent galaxies at redshifts $z = 3 \sim 5$ over the last decade, there have been numerous attempts to reconcile their unexpected presence with current galaxy formation models, which do not yet offer an explanation for such a large stellar mass build-up so shortly after the Big Bang. The JWST NIRSpec observations comprising the spectroscopic component of the JADES DEEP program are perfectly suited to address these concerns, providing access to the rest-frame optical wavelength window containing the required diagnostic spectral features, at the required signal-to-noise ratio and grating resolution.

We present an unprecedented study of the stellar populations in high-redshift massive quiescent galaxies identified in JADES DEEP NIRSpec observations through an analysis of key rest-frame optical absorption features to reconstruct their star-formation histories and formation timescales. We rely on the Balmer absorption features to determine age constraints and the timing of the last star-formation episode, as well as metal absorption features to constrain the durations of previous star-formation episodes, metallicities, and chemical abundances trends. The importance of studying such features cannot be underestimated, as the alpha-abundance, as measured through metallic absorption lines like Mgb, can classify the galaxy interstellar medium as either having been enriched by short- or long-lived stars, thereby offering a major clue to the star formation timescale. Likewise, the measured value of metallicity through [Fe/H] can indicate if these galaxies were built on a very short time scale from low-metallicity gas.

In addition to determining element abundances and SFH through individual line analysis, we attempt to obtain the most robust characterization of JADES high-z massive quiescent galaxies with full spectrophotometric fitting by performing SED fits to recover the full star-formation history, fitting for velocity, velocity dispersion, and numerous element abundances to further constrain galaxy age, metallicity, and alpha-abundance.

SPT0311-58 Simultaneous: Mid-IR Morphology and Number Counts

Steven Gillman and MIRI European Consortium GTO

In the last few decades, HST-based studies have identified the emergence of the Hubble sequence occurs around z~1.5, with the majority of galaxies above z=2 exhibiting peculiar rest-frame optical morphologies. More recent JWST studies have identified a population of regular 'Hubble-like' disk galaxies at much earlier cosmic times, in addition to a population of 'hidden' red galaxies around Cosmic Noon. These new populations pose difficult questions for our current theories of large-scale structure formation in the Universe and require further deep multi-wavelength observations to constrain their properties.

To this end, we present the multi-wavelength morphological and structural analysis of galaxies observed in a 4.6 arcminute field covering SPT0311-58. Utilizing the deepest JWST/MIRI observations, to date, at 5.6, 7.7 and 10 micron from the MIRI European Consortium GTO we analyze the galaxies' multi-wavelength morphology, using both non-parametric and parametric analysis tools. Exploiting the unprecedented depth of JWST/MIRI observations we further define the number counts in each filter, as a function of galaxy properties, as well as combining the JWST imaging with multi-wavelength data from HST and ALMA to empirically constrain the properties of the galaxies.

Early JWST imaging reveals strong optical and NIR color gradients in galaxies at cosmic noon

Tim B. Miller, Kate Whitaker, Erica Nelson, Pieter van Dokkum and others

Recent studies have shown that galaxies at cosmic noon are redder in the center and bluer in the outskirts, mirroring results in the local universe. However, investigating the physical causes is impossible with HST photometry which traces the rest-frame optical. Longer wavelengths are needed. In this talk I will present recent results investigating the causes of color gradients in the early universe using JWST. We use NIRCam images from the CEERS survey to construct resolved spatially-resolved rest-frame U-V vs. V-J color-color diagrams for a sample of 54 galaxies at z~2. We model the light profiles using imcascade, a Bayesian implementation of the Multi-Gaussian expansion (MGE) technique which flexibly represents galaxy profiles using a series of Gaussians. We find star-forming galaxies generally have red centers and blue outskirts in both U-V and V-J colors implying strong central dust attenuation with a smaller fraction showing gradients in star-formation. In quiescent galaxies we find a diversity of U-V and V-J color profiles, with roughly one-third showing star-formation in their center. These results showcase the potential of JWST to study the resolved stellar populations of galaxies at cosmic noon.

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The Quest for Understanding Star-Formation and Galaxy Growth at Cosmic Noon with JWST

LE BAIL Aurélien, Emanuele DADDI, David ELBAZ and the CEERS Team

It is well known that galaxies at cosmic noon are redder in the center and bluer in the outskirts.

The JWST/NIRCam spatial resolution allows to spatially resolve these galaxies, hence to investigate their color gradients. In preparatory work, we built the deepest far-infrared (FIR) catalog in the EGS field using the state-of-the-art “super-deblending” technique, gathering photometry from Spitzer, Herschel, SCUBA2, AzTEC and VLA. Based on this “super-deblended” FIR catalog, we selected 31 Herschel-detected FIR-limited galaxies with 1.5<z<4 that fall in the CEERS field observed in June 2022. The exceptional resolution of the NIRCam images allows to resolve these galaxies up to 4.4μm. In a large fraction of the Herschel galaxies, we identify very red, deeply attenuated, compact star-forming cores, analogous to the ALMA compact galaxies previously discovered. Around the compact cores large disk-like structures are found that often display sub-regions with largely different NIRCam colors. These uniform disk-patches are driven by attenuation, probably pointing to complex star formation histories that affect in turn different parts of the galaxies or dust-cleaning mechanisms of sub-regions. The patches are sometimes quiescent, and in some case, we observe fully quiescent disks around the highly star forming cores. The disk mass distribution is generally lopsided, both in the star-forming and quiescent cases. It appears that an important fraction of galaxies grows lopsided accretion-fed disks that at some point trigger a nuclear starburst (probably torque-induced) and finally get devoid of gas in the outskirts, in outside-in quenching fashion. This work demonstrates the major impact JWST/NIRCam will have on the understanding of galaxy mass growth at cosmic noon.

Brown dwarfs as benchmark analogs to planetary companions

'JWST Observations of the Brown Dwarf HD 19467 B

Alexandra Greenbaum, JORGE LLOP-SAYSON, BEN LEW, GEOFFREY BRYDEN, TOM ROELLIG, MARIE YGOUF, B.J. FULTON, DANIEL HEY, DANIEL HUBER, MICHAEL MEYER, JARRON LEISENRING, MARCIA RIEKE, MARTHA BOYER, DOUG KELLY, KARL MISSELT, JOHN STANSBERRY, LAURIE E. U. CHU, MATTHEW DE FURIO, DOUG JOHNSTONE, and CHARLES BEICHMAN

HD 19467 B, a previously imaged brown dwarf with a known radial velocity trend, was observed with JWST's NIRCam at six wavelengths spanning 2.5-4.6 µm with the Long Wavelength Bar coronagraph without a reference star. We perform an updated analysis of the properties of the HD 19467 system, including NIRCam photometry in six filters, new radial velocities from Keck/HIRES, and photometric data from TESS to constrain the properties of the host star. We apply the new relative astrometry and radial velocity measurements to an updated orbital analysis. We also do a preliminary comparison of the new photometry with atmospheric and evolutionary models. This work notably demonstrates post-processing using synthetic PSFs developed from contemporaneous maps of the telescope's optical configuration, identifying a potential, more efficient observational strategy for some high contrast observations.

The End of the Dark Ages (Large-scale structure of the universe, first stars, reionisation, high-redshift universe)

Probing the Inner Density Profile of Galaxy Clusters

Catherine Cerny, Mathilde Jauzac, David Lagattuta, Richard Massey, and Alastair Edge

Galaxy clusters are the most massive gravitationally-bound objects in the universe, and analysis of their structure can yield many fascinating answers and equally fascinating questions about the nature of the physics that holds them together. The presence of dark matter in galaxy clusters is a particularly interesting question, and there are many techniques that are currently being used to study everything from the 'core-cusp' tension in cluster cores to the exact distribution of DM throughout the clusters. Of these techniques, strong gravitational lensing is uniquely positioned to benefit from JWST's high resolution imaging capabilities, as the increased amount of substructure visible in JWST imaging allows lensing models to use an even larger number of constraints to effectively pinpoint the structure and location of DM. These models can be further constrained with the use of ground-based IFU spectroscopy from the MUSE instrument, which can be used to measure 2-D galaxy kinematics. The combination of high-resolution JWST imaging and MUSE spectroscopy promises to yield very well-constrained lens models, which will provide crucial information about the dark matter inside galaxy clusters. I will present completed models from lensing and MUSE spectroscopy, and then show to what degree these models can be improved with JWST imaging. I will use this information to discuss how we can effectively constrain the shape of the density profiles in galaxy clusters with strongly lensed arcs, and I will additionally comment on what future science these two powerful instruments can provide in this area.

ALMA observation of a z>10 galaxy candidate and its foreground neighbors from the GLASS-JWST

Ilsang Yoon, Christopher L. Carilli, Seiji Fujimoto, Marco Castellano, Emiliano Merlin, Paola Santini, Min S. Yun, Eric J. Murphy, Intae Jung, Caitlin M. Casey, Steven L. Finkelstein, Casey Papovich, Adriano Fontana, Tommaso Treu, and Jonathan Letai

I will introduce our recent ALMA DDT program that observes [OIII] 88 micron line and continuum emission from one of the earliest JWST discovered z>10 galaxy candidates (GHZ1) in the GLASS-JWST Early Release Science Program. Although there was no strong (>5 sigma) line or continuum emission detected, we found a tentative emission feature from the location of GHZ1 (within the uncertainty of astrometric accuracy of ALMA and JWST) with 4.4 sigma peak S/N. Our noise analysis suggests that the ALMA cube noise is close to Gaussian noise and the random chance of the appearance of this tentative emission in the cube is only 0.0032%. However, this tentative emission needs to be verified by further observation. The near- and far-IR SED modeling based on the JWST NIRCam photometry and the 3 sigma upper limit of the ALMA continuum flux density, suggests a cold dust (Td<30K) in GHZ1. The 5 sigma upper limit of the [OIII] luminosity with larger error of the SFR estimate, are consistent with the properties of low metallicity galaxies and those of local starburst galaxies. I will also present the serendipitous detections of FIR continuum from six sources in the field of view that have the JWST counterparts, and introduce our analysis on the SED model using JWST and ALMA data. Lastly, I will discuss the prospects for the far-IR observation of those JWST discovered high-redshift galaxy candidates, which will be highly synergistic with the JWST observations from the current and future cycles.

Discovery of surprisingly metal rich galaxies at redshift 4

Bo Peng, Amit Vishwas, Cody Lamarche, Gordon Stacey, Thomas Nikola, Henrik Spoon, Carl Ferkinhoff, Christopher Rooney, and Catie Ball

We report the discovery of super-solar metalicity, and a companion source, of a high lensed dusty star forming galaxy system SPT0418 at redshift 4.2. The companion is discovered in Hα using JWST/NIRSPEC data. Both the highly lensed ring and the companion source are detected in multiple lines. We measure the absolute metallicity (O/H) using N2 index and S23 index. We found that using both methods the ring has a metallicity of about 1.5 × solar, and the companion metallicity is 0.5 × solar. The Nitrogen-to-Oxygen abundance ratio (N/O) estimated by N2S2 index also suggests a super-solar N/O of the main source. The discovery of the companion source suggests the prevalence of low mass companions and shows JWST's unprecedented ability in finding and studying intermediate to low mass star forming galaxies in the early Universe. The surprisingly high O/H and N/O challenges our understanding of the early Universe. Comparing the values to the chemical evolution models, galaxy with 1.5 × solar metallicity at redshift 4.2 requires the formation to start shortly after the Big Bang, and sustaining a high star formation efficiency across the cosmic age of 1.4 Gyr. The high metallicity is also in contradiction to the weak [N II] 122 and 205 μm detection, drawing tension between the optical and far-infrared abundance estimations.

PASSAGE--Parallel Application of Slitless Spectroscopy to Analyze Galaxy Evolution

Claudia Scarlata and PASSAGE team

PASSAGE is a 591-hour JWST program that will conduct 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.

PASSAGE 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 $z>7$, PASSAGE 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 an unbiased determination of the EW(Ly-alpha) 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.

Probing high-redshift galaxies with “exotic” cluster lenses

David Lagattuta

Hyperbolic-umbilic (H-U) lenses are an “exotic” sub-class of gravitational lens characterized by extreme (>100x) magnifications, opening a detailed window into resolved physical properties of distant source galaxies. Found in the innermost cores of galaxy clusters (<100 kpc from the centre), H-U systems are also sensitive probes of the cosmologically important central slope of dark matter mass distribution. Though historically rare — until recently only a handful examples could be found in the literature — the sensitivity of modern instruments have enabled us to increase the number of known H-U lenses by nearly a factor of ten. This represents the first statistically robust collection of these lenses ever compiled. In a recent paper, we demonstrated the power of studying H-U lenses with optical imaging and spectroscopy, revealing highly structured sources at z~3 that placed new constraints on large-and small-scale dark matter distributions. As part of this work, we also set the stage for extending the analysis to higher redshifts using infrared data. Therefore, In this presentation I will discuss the current state of known H-U lenses and demonstrate improvements that advanced JWST imaging and spectroscopy will bring to the sample. With recent estimates suggesting z>6 H-U sources will be found in ~10% of all clusters observed with JWST, the sensitivity and high resolution of NIRCAM and NIRSPEC will make these instruments the only ones capable of simultaneously probing unprecedented details of cosmology and the physical properties of galaxies in the high-redshift universe.

First Sample of z>6 [OIII]+Halpha Line Emitters through JWST/NIRCam Wide-Field Slitless Spectroscopy: Physical Properties and Line Luminosity Functions

Fengwu Sun, Eiichi Egami, Nor Pirzkal, and Marcia Rieke (JWST/NIRCam Commissioning Team)

In this presentation, I will convince you that the Wide-Field Slitless Spectroscopic (WFSS) mode of JWST/NIRCam will become a game changer for the study of the high-redshift Universe. The in-flight spectral sensitivity of NIRCam WFSS is 20-40% higher than the pre-launch prediction, and it started to unveil the rest-frame optical emission lines (e.g., [OIII] 5007 and Hα) of z>6 galaxies even with the shallow (10~20-min integration) commissioning data taken in April 2022. In two of our recent works, we discovered four z>6 [OIII]+Hα line emitters using the flux-calibration data of NIRCam/WFSS. I will show the first [OIII]/Hβ-[NII]/Hα BPT diagram of galaxies in the Epoch of Reionization, and a nice mass-metallicity relation that suggests rapid metal enrichment with galaxies at z>6. We also obtain the first direct measurement of [OIII]5007 and Hα luminosity functions at z>6, both were under-predicted by certain previous cosmological simulations by a factor of 10~20! Our studies suggest an enhanced ionizing photon production rate in the early Universe, and the ubiquity of strong Hα and [OIII] line emitters in the Epoch of Reionization, both will be further uncovered in the era of JWST.

MIRI imaging of the Hubble Ultra Deep Field

Göran Östlin and MIRI-European Consortium

Within the MIRI European Consortium (MIRI-EC) guaranteed time observations (GTO), 60 hours of telescope time will be invested on MIRI imaging in the F560W filter of a single pointing centered on the Hubble Ultra Deep Field (HUDF). Parallell observations will be obtained with NIRCAM (~40 hours, imaging) and NIRISS (20 hours slitless

spectroscopy) targeting two other areas within GOODS-S with available HST imaging. We will describe observational strategy and the science goals. The scheduling window is during the first two weeks of December 2022, likely too near the workshop for us to be able to show any real science results, but we may be able to present some preliminary results.

Candidate Galaxies at z > 11: too many, and too bright?
Haojing Yan

An early JWST result surprising to many is the bright candidate galaxies at z > 11 selected by various teams. Simply put: there seem to be too many of them, and a lot of them seem to be too bright. Both the classic dropout method and the photometric-redshift method have been employed in selecting these candidates. It does not seem that resorting to contamination can explain all such candidates. Here we focus on the results based on the data from the ERO program on SMACS 0723-73 and the PEARLS GTO program. The likely implications are discussed. A significant fraction of these z > 11 candidate galaxies are bright enough of the JWST spectroscopy, and such observations are urgently needed to put the future JWST high-z studies on a solid footing.

Severe Interloper Contamination Among High Photo-z Galaxies in Cluster Fields
Jiashuo Zhang, Tom Broadhurst, and Jeremy Lim

The Luminosity Function (LF) of galaxies at different cosmic epochs provides a fundamental test of cosmological models for galaxy formation and evolution as well as the nature of Dark Matter. By taking advantage of gravitational lensing by massive galaxy clusters, galaxy LFs can be measured to fainter luminosities and higher redshifts than would otherwise be possible. On the other hand, such measurements are complicated by the difficulty in separating faint cluster members from high-z galaxies based solely on their spectral energy distributions (SEDs), especially when observations are restricted primarily to optical wavelengths. Here, we investigate the degree to which such difficulties may plague photo-z catalogs of clusters in the Hubble Frontier Fields (HFF). To perform this test, we employ the concept of magnification bias, whereby the lensing magnification affects the observed number density of galaxies by lowering the luminosities accessible but at the same time reducing the volume of sky probed. Using the galaxy LFs from HFF parallel fields, we show that the number density of galaxies in the HFF cluster fields is: (i) consistent with that predicted by magnification bias at z~2, where the photo-z's of galaxies can be more readily distinguished from those of cluster members at z~0.3; and (ii) in strong conflict with that predicted by magnification bias at z~4, precisely where the SEDs of high-z star-forming galaxies resemble those of cluster members at z~0.3. We show that ~40% of 3.5 < z_phot < 5.5 galaxies are in fact cluster members lying at the faint end of the cluster red sequence. We are currently investigating whether SEDs constructed by combining HST with JWST can help break this impasse, crucial for investigating the faint end of galaxy LF that provides the strongest leverage between different cosmological models and the nature of Dark Matter.

Sub-mm galaxy surveys in James Webb Space Telescope North Ecliptic Pole Time Domain Field (S2TDF) - To reveal the hidden star formation in the high-z universe

Minhee Hyun Myungshin Im (Seoul Nat'l Uni.), Ian Smail (Durham Univ.), William D. Cotton (NRAO), Jack E. Birkin (Durham Univ.), Satoshi Kikuta (Tsukuba Univ.), Hyunjin Shim (Kyungpook Univ.), Christoper N. A. Willmer (Steward Observatory), James J. Condon (NRAO), Rogier A. Windhorst (Arizona State Univ.), Seth H. Cohen (Arizona State Univ.), Rolf A. Jansen (Arizona State Univ.), Chun Ly (Steward Observatory), Yuichi Matsuda (NAOJ), Giovanni G. Fazio (Havard & Smithsonian), A. M. Swinbank (Durham Univ.), and Haojing Yan (Missouri Univ.)

In this talk, we will introduce the study of sub-mm galaxies (SMGs) in the JWST Time-Domain Field covering a ~ 14’ diameter sky area near the North Ecliptic Pole. JWST Time Domain Field will be targeted by one of the JWST Guaranteed time Observation programs and reach the depth reaching to ~29 mag. This JWST-TDF observation will improvement our knowledge of about the dust obscured galaxies highly contributing to the cosmic star formation in the high redshift. We surveyed sub-mm galaxies which are thought to be high-z dusty star-forming populations in the JWST TDF field using James Clerk Maxwell Telescope SCUBA-2 from 2018 to 2020. With our deep 850 um observation with a noise level of 1.0 mJy/beam, we newly discovered 114 SMGs and found that 66 sources have radio counterparts by matching 3-GHz Karl J. Jansky Very Large Array (VLA). We also performed SED fitting for 61 SMGs matched with opt/NIR data, and found that SMGs at SNR>4 have median values of z = 2.22, star formation rates of 300 Msol/year and typical cold dust masses of 5.9x10^8 Msol similar to bright sub-mm galaxies from other surveys. We suggest that the large cold dust masses of the SMGs corresponding to large cold gas masses are the key factor to the high star formation rates of the populations.

Too early to claim a z~20 galaxy? Identification of high-redshift galaxy candidates in JWST early release programs

Takahiro Morishita and Massimo Stiavelli

The James Webb Space Telescope started its science operation in June 2022 and has already given us a new view of the universe. Within only a few weeks of the initial data release of the Early Release Observations program, several studies reported identification of early galaxy candidates at z>7, some up to z~20 (!). Identification of this many galaxy candidates undoubtedly demonstrates the power of the new telescope but at the same time leads us to an idea that the universe may be much more efficient in producing baryons than is thought in our current cosmological framework. Interestingly, however, only a handful of those candidates overlap among studies, despite using the same dataset from the same field, leaving the interpretation of the scientific implication still pending. In this contribution, we will present our careful selection of high-z galaxy candidates that combines color-cut and photometric redshift analyses. Our careful selection identified 4 robust candidates, which is by far less than other studies, and none of them are at z>15. We will compare candidates that are selected in other studies but not in ours and discuss what may make the selection outcome different. Once we overview the selection of high-z candidates, we will present the observed properties of the final candidates in detail, by focusing on their rest-frame SED and morphology enabled by the long-wavelength sensitivity and spatial resolving power of JWST.

JWST reveals a possible z $\sim$ 11 galaxy merger in triply-lensed MACS0647-JD

Tiger Hsiao, Dan Coe, and Comsic Spring Team

MACS0647-JD is a triply-lensed z $\sim$ 11 galaxy originally discovered with the Hubble Space Telescope. Here we report it is clearly resolved as two galaxies (or perhaps two clumps within a galaxy) in new JWST NIRCam imaging. These galaxies are very small, with stellar masses $\sim 10^8 M_\odot$ and radii r < 100 pc. The brighter larger galaxy “A” is intrinsically very blue (β = −2.7), likely due to very recent star formation and no dust, and is spatially extended with an effective radius $\sim$ 70 pc. The smaller galaxy “B” appears redder, likely because it is older (100–200 Myr) and with mild dust extinction (AV $\sim$ 0.1 mag), and a smaller radius $\sim$ 20 pc. With an estimated stellar mass ratio of (1.5 – 5) : 1 and physical separation $\sim$ 400 pc, we may be witnessing a galaxy merger 400 million years after the Big Bang. We also identify a candidate companion galaxy C $\sim$3 kpc away. The combined light from these galaxies

A+B is magnified by factors of $\sim$8, 5, and 2 in three lensed images JD1, 2, and 3 with F356W fluxes $\sim$322, 203, 86 nJy (AB mag 25.1, 25.6, 26.6). MACS0647-JD is significantly brighter than other galaxies recently discovered at these redshifts with JWST. The photometric redshift is confidently z = 10.6 ± 0.2 based on photometry measured in 6 NIRCam filters spanning 1–5 µm, out to 4300Å rest-frame. JWST NIRSpec observations planned for January 2023 will deliver a spectroscopic redshift and more detailed study of the physical properties of MACS0647-JD.

A Comprehensive Study on Galaxies at z~9-17 Found in the Early JWST Data

Yuichi Harikane

We conduct a comprehensive study on dropout galaxy candidates at z∼9−17 using the first 90 arcmin2 JWST/NIRCam images taken by the ERO and ERS programs. With JWST simulation images, we find that a number of foreground interlopers are selected with a weak photo-z determination (Delta_chi2>4). We thus carefully apply a secure photo-z selection criterion (Delta_chi2>9) and conventional color criteria with confirmations of the ERO NIRSpec spectroscopic redshifts, and obtain a total of ~20 dropout galaxies at z∼9−17, including two candidates at zphot=16.45+0.09−0.32 and 16.66+1.86−0.34. We perform thorough comparisons of dropout galaxies found in our work with recent JWST studies, and conclude that our galaxy sample is reliable enough for statistical analyses. We also confirm that our bright sources are good candidates for high redshift galaxies with the latest NIRCam calibration. We derive the UV luminosity functions at z∼9−17, and confirm that our UV luminosity functions at z∼9 and 12 agree with those determined by previous HST and JWST studies. The cosmic star-formation rate density decreases from z∼9 to 12, and perhaps to 17, but the densities at z∼12−17 are higher than the constant star formation efficiency model. Interestingly, there are six bright galaxy candidates at z∼11−17 with MUV<−19.5 whose stellar masses are very high, 10^8−9Msun. Because a majority (∼70%) of them show no signatures of AGNs in their morphologies, the high cosmic star-formation rate densities and the existence of these stellar massive galaxies are explained by no suppression of star-formation by the UV background radiation at the pre-reionization epoch or an efficient UV radiation production by a top-heavy IMF possibly with Population III-like star formation. In this talk, I will also present the latest results from new NIRCam datasets including a lensing field to probe the faint end of the luminosity function calibrated with NIRSpec spectroscopic data obtained this fall.

Stellar Physics and Stellar Life Cycle (transient phenomena, stellar physics)

JWST ERO Imaging of the Planetary Nebula NGC 3132 Reveals Messy Death in a Multiple Star System

Joel H. Kastner, Orsola De Marco, Mikako Matsuura, and the JWST Planetary Nebula Community Team

Planetary nebulae (PNe), the ejected, ionized envelopes of red giant stars, trace the fatal mass-losing phases of evolution of 90% of stars initially more massive than the Sun. JWST observations of PNe hold promise to reveal a wealth of PN macro and microstructures, providing unique insight into fundamental astrophysical processes including colliding winds, plasma instabilities, binary star interactions, and the circumstellar environments of newly formed white dwarfs. A broad swath of the community of planetary nebula researchers has analyzed JWST Early Release Observation (ERO) imaging of the nearby PN NGC 3132 in the context of other recent observations and new modeling of the object (De Marco et al., Nature Astronomy, in press), and we present those results here. The JWST ERO images have revealed telltale signs of various interactions among the components of a hierarchical multiple star system, including a highly structured, extended halo of H2 gas surrounding the ionized PN central bubble and an infrared excess at the central, mass-losing star that is interpreted as a dusty, circumbinary disk. These ERO results for NGC 3132 serve as pathfinders for future JWST observations of PNe aimed at elucidating the evolution of interacting multiple-star systems, with implications for supernovae and gravitational wave systems.

NIRSpec IFU observations of SN 1987A

B. A. Sargent, Josefin Larsson, Claes Fransson, M. J. Barlow, Joris Blommaert, Patrice Bouchet, Alain Coulais, Ori Fox, Rene Gastaud, Alistair Glasse, Nolan Habel, Alec S. Hirschauer, Jens Hjorth, Jeroen Jaspers, Olivia Jones, Patrick J. Kavanagh, Oliver Krause, Ryan M. Lau, Laura Lenkić, Margaret Meixner, Omnarayani Nayak, Armin Rest, Tea Temim, Tuomo Tikkanen, Roger Wesson, and Gillian Wright

In 1987, the nearest supernova (SN) since the advent of modern telescopes and detectors occurred in the Large Magellanic Cloud (LMC), allowing for a revolution in our ability to study these rare but exceedingly important astronomical events. The spatially resolved ejecta and circumstellar medium in SN 1987A offer a uniquely detailed view of a stellar explosion. We present the initial results of NIRSpec IFU observations of SN 1987A (PID 1232), which provide spatially resolved spectroscopy of the full NIR range from 1-5 microns for the first time. The observations allow for 3D reconstructions of both the inner metal-rich ejecta and the reverse shock, which gives new insight into the properties of the explosion and progenitor. The full spectrum also provides new constraints on the ejecta's physical conditions, including the molecular hydrogen's excitation mechanism.

Gravity-dependent Sedimentation of Dust Clouds in Ultra-cool Atmospheres
Genaro Suarez, Stanimir Metchev, and Jacqueline Faherty

Analysis of all archival 5--14 micron spectra of field ultra-cool dwarfs from the Infrared Spectrograph on the Spitzer Space Telescope has shown that absorption by silicates in the 8--11 micron region is seen in most L-type (1300 K to 2200 K) dwarfs. The silicate absorption is caused by silicate-rich clouds in the upper atmospheres of L dwarfs, and is strongest in mid-L types. Herein we compare the average spectra of mid-L dwarfs with low (≲104 cm s-2) and high (≳105 cm s-2) surface gravity. The mean silicate absorption profile of low-gravity mid-L dwarfs matches absorption signature expectations for ~1 micron-sized and/or forsterite- or pyroxene-bearing (Mg2SiO4 or MgxFe1-xSiO3) silicate grains. High-gravity mid-L dwarfs have silicate absorption better represented by lighter grains: either smaller in size (~0.1 micron) or composed of enstatite (MgSiO3). This is the first observational evidence for gravity-dependent sedimentation of dust clouds in ultra-cool atmospheres. Our study provides reference silicate absorption profiles for interpreting JWST observations of giant planet analogs. We compare the JWST MIRI spectrum of VHS 1256 b to the average silicate absorption profiles and found it lies between the low- and high-surface gravity profiles, which is consistent with a gravity-sensitive cloud sedimentation.

A JWST Near- and Mid-Infrared Nebular Spectrum of the Type Ia Supernova 2021aefx
Lindsey A. Kwok

Type Ia supernovae (SN Ia) have important implications on our understanding of cosmology and astrophysics, yet we still lack a detailed understanding of their progenitor systems and explosion physics. Nebular phase spectroscopy at late times reveals the SN ejecta when they have expanded, allowing us to directly probe the ejecta structure. We present JWST near- and mid-infrared spectroscopic observations of the normal Type Ia SN 2021aefx in the nebular phase at 255 days past maximum light. The JWST NIRSpec and MIRI spectra, combined with ground-based optical data, constitute a complete optical + NIR + MIR nebular SN Ia spectrum covering 0.3-14 microns. This spectrum unveils the previously unobserved 2.5-5 micron region, revealing strong nebular iron and stable nickel emission indicative of high-density burning that can constrain the ejecta mass. The data show a significant improvement in sensitivity and resolution compared to previous Spitzer MIR data. We identify numerous NIR + MIR nebular emission lines from iron group elements and also lines from the intermediate-mass element argon. The argon lines extend to higher velocities than the iron-group elements, indicative of stratified ejecta that are a hallmark of delayed-detonation or double-detonation SN Ia models. We present fits to simple geometric line profiles to investigate the emissivity structure of the ejecta. As part of our work, we identified an issue with the MIRI/LRS slit wavelength calibration and developed a new wavelength solution based on observations of the calibration star VFTS 822 that has informed updates to the JWST pipeline. Continued observations of SN 2021aefx and other SN Ia with JWST will be transformative to the study of SN Ia composition, ionization structure, density, and temperature, and will provide important constraints on progenitor and explosion models.

Supernovae are, in fact, dust factories!

Melissa Shahbandeh, Jennifer Andrews, Richard Arendt, Antonia Bevan, Geoffrey Clayton, Ilse Delooze, Luc Dessart, Eli Dwek, Mike Engesser, Alex Filippenko, Ryan Foley, Ori Fox, Suvi Gezari, Sebastian Gomez, Shireen Gonzaga, Jacob Jencson, Joel Johansson, Mansi Kasliwal, Kelsie Krafton, Ryan Lau, Anthony Marston, Dan Milisavljevic, Ricky O'Steen, Justin Pierel, Armin Rest, Arka Sarangi, Matt Siebert, Michael Skrutskie, Nathan Smith, Lou Strolger, Tamás Szalai, Tea Temim, Samaporn Tinyanont, Schuyler Van Dyk, Qinan Wang, Brian Williams, Weikang Zheng, and Szanna Zsíros

Core-collapse supernovae 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. 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 30 years, no other SNe have measured dust masses later than 5 years post-explosion. This talk presents the largest dust masses ever measured in SNe using images of SN 2004et and SN 2017eaw obtained with JWST MIRI. SN 2004et and SN 2017eaw are two of the dustiest, nearby extragalactic Type IIP SNe. These two SNe are more than 5 years old and measure dust masses closer to that of SN 1987A and more than any other SNe to date. These results have filled the gap between the existing observations of warm dust in SNe IIP and the cold dust in SN 1987A. We also present how we distinguish between pre-existing CSM dust and newly formed dust by comparing the dust and shock radii in these two SNe.

Deep NIRCam imaging of Supernova 1987A

Mikako Matsuura and NIRCam SN 1987A team

At a distance of 50 kpc, Supernova (SN) 1987A is the nearest SN explosion detected from the moment of explosion in 400 years. Over the last 30 years, SN 1987A provided many discoveries and has shown unprecedented detail of how a SN remnant evolves at multiple wavelengths, via observations by ground-based observatories, HST, Chandra, Herschel, ALMA etc. JWST/NIRCam is going to add a new page of discoveries for Supernova 1987A.

The inner ejecta of supernova 1987A contains a large amount of dust (about half a solar mass), which hides some structures in the optical HST images. Near-infrared light can start penetrating through ejecta dust. Deep and high-angular resolution NIRCam images unveil unprecedented details of Supernova 1987A, some of which have never been seen before. These structures demonstrate how the supernova explosion triggered instabilities and fragmented gas into small clumps in the ejecta. Furthermore, NIRCam captures the sites where forward SN shocks are sweeping through the circumstellar material, and then reverse shocks approach the inner ejecta. We are searching for evidence the pulsar in this supernova.

Photometric abundances and age of the globular cluster 47 Tucanae from JWST observations of the lower main sequence and brown dwarfs

Roman Gerasimov, Adam Burgasser, Derek Homeier, Ilaria Caiazzo, Harvey Richer, Matteo Correnti, Aaron Boley, Andrea Dieball, Jeremy Heyl, Aryanna Schiebelbein, and Pier-Emmanuel Tremblay

47 Tucanae is the brightest of the so-called “normal” globular clusters, characterized by uncorrelated iron peak and light element abundances that cannot be explained by conventional chemical enrichment processes operating in field stars and open clusters. The spread in abundances among the cluster members may be independently inferred from the spectroscopy of the red giant and subgiant stars, as well as from photometric colors of the chemically sensitive lower main sequence stars and brown dwarfs.

We present updated photometric abundances for this globular cluster, derived from the new preliminary main sequence photometry in the ultrawide F150W2 and F322W2 bands of JWST NIRCam in combination with previously published optical and near-infrared photometry with the Hubble Space Telescope (HST). The observed scatter in all possible JWST/HST color combinations is interpreted by comparison to new theoretical isochrones, tailored to the chemical composition of 47 Tucanae. The isochrones are derived from a custom grid of evolutionary models and model atmospheres that allow for variations in enhancements of individual elements. The distribution of the new photometric abundances is compared to the spectroscopic counterpart in literature and possible reasons for the observed discrepancies are discussed.

The theoretical color-magnitude diagram in the JWST bands is extended beyond the faint cut-off of the main sequence and into the brown dwarf regime in anticipation of the upcoming more detailed analysis of our JWST observations that is expected to reveal these ultracool objects in globular clusters for the first time. The expected constraints from JWST brown dwarf photometry on the cluster age and chemical composition are derived and compared to the published and new constraints based on the main sequence photometry, the color-magnitude turn-off point and the spectroscopic abundance measurements.

JWST observations of dusty supernovae thus far

Samaporn Tinyanont, Jennifer Andrews, Richard Arendt, Antonia Bevan, Geoffrey Clayton, Ilse Delooze , Luc Dessart, Eli Dwek, Mike Engesser, Alex Filippenko, Ryan Foley, Ori Fox, Suvi Gezari, Sebastian Gomez, Shireen Gonzaga, Jacob Jencson, Joel Johansson, Mansi Kasliwal, Kelsie Krafton, Ryan Lau, Keiichi Maeda, Anthony Marston, Dan Milisavljevic, Ricky O'Steen, Justin Pierel, Armin Rest, Itsuki Sakon, Arka Sarangi, Melissa Shahbandeh Matt Siebert, Michael Skrutskie, Nathan Smith, Lou Strolger, Tamás Szalai, Tea Temim, Kaew Tinyanont, Schuyler Van Dyk, Qinan Wang, Brian Williams, Weikang Zheng, and Szanna Zsíros

Dust appears in the Universe before 1 Gyr after the big bang. There has not been enough time for efficient local dust factories, evolved intermediate and low mass stars, to form. These observed dust grains must come from massive stars with brief evolutionary timescales. In their short lifetimes, they produce dust in their outflows and in their resulting death in core-collapse supernovae (CCSNe). In virtually all CCSNe, an appreciable amount of dust is inferred from observations, in particular by Spitzer. Characterizing the dust in these systems has broad appeal. If newly formed, the inferred dust masses could determine whether CCSNe form sufficient amounts of dust to contribute to the cosmic dust budget. If pre-existing in the CSM, its illumination by the expanding SN shock allows us to trace the mass-loss history of the progenitor system. The properties of pre-existing dust will also determine whether the grains can survive the passage of the SN shock. JWST's unprecedented infrared sensitivity opens up new phase spaces, allowing us to probe SN dust at distances, temperatures, and epochs previously inaccessible by any other telescope, including Spitzer. I will discuss our three JWST observing programs targeting different types of nearby CCSNe. We already have a unique data set. Already, we have secured MIRI photometry of two SNe IIP and have scheduled MIRI MRS and NIRSpec IFU spectra of the mysterious SN 2014C, which transitioned from a normal Type Ib to an interacting Type IIn mere months post-explosion. We also have scheduled MIRI MRS observations of a sample of strongest interacting Type IIn supernovae. I will also present other CCSNe fortuitously observed by other programs targeting nearby galaxies, especially PHANGS. I will focus on how to use these observations to disentangle the origin and heating mechanism of the dust and the implications of the results of dust growth and pre-SN mass loss in SNe.

Planetary Systems and the Origins of Life (Planet formation, exoplanets, solar system phenomena)

Rogue planets and brown dwarfs with JWST
Aleks Scholz

Free-floating (or rogue) planets are planets that are liberated (or ejected) from their host systems. Although simulations predict their existence in substantial numbers, direct observational evidence for free-floating planets with masses below ~5 MJup is still lacking. Several cycle-1 observing programs with JWST aim to hunt for them in four different star-forming clusters. These surveys are designed to be sensitive to masses of 1-15 MJup (assuming a hot-start formation), which corresponds to spectral types of early L to late T for the ages of these clusters. If the existing simulations are not wide off the mark, we show here that the planned programs are likely to find numbers of giant rogue planets that correspond to 1-5% of the total cluster population. In contrast, the number of low-mass brown dwarfs forming like stars is expected to be an order of magnitude lower. That means, if a population of L and T dwarfs were to be found in these JWST surveys, it is expected to be predominantly made up of rogue planets.

One transit of TRAPPIST-1c with NIRSpec/PRISM
Alexander Rathcke

The TRAPPIST-1 system hosts seven transiting terrestrial exoplanets amenable to atmospheric characterization, providing a unique laboratory for comparative terrestrial planetology. If the TRAPPIST-1 planets retain atmospheres, they are likely to be heavy, secondary atmospheres, with transmission features in the near-infrared at the 50-100 ppm level. JWST has the precision and wavelength coverage necessary to detect such features. Here we report the first look at the transmission spectrum of TRAPPIST-1c observed with NIRSpec/PRISM. This single transit constitutes a quarter of our program, with three additional transits scheduled for late 2023. One transit does not allow for the detection of atmospheric features in TRAPPIST-1c, however, we do find that the transmission spectrum exhibits a downward slope toward the bluest channels with an amplitude several times larger than the signal strength expected from a secondary planetary atmosphere and likely arising from unocculted stellar faculae. Our findings demonstrate the spectroscopic precision achievable with JWST for terrestrial-size exoplanets and that we must account for unocculted stellar heterogeneities when interpreting transmission spectra if we are to characterize the atmosphere of TRAPPIST-1c and similar worlds.

The NIRSpec spectrum and NIRCam photometry of the unusually red Y-dwarf WISE1828

Ben Wei Peng Lew and NIRCam GTO team

WISE 1828+2650 is one of the coldest brown dwarfs with an effective temperature of less than 400K. Because of the cold temperature, WISE1828 is very faint at the near-infrared wavelengths (e.g., J = 23.48, Leggett et al. 2013) even though it is only at around 10pc (Kirkpatrick et al. 2019). Based on the brown dwarf evolution models (Marley et al. 2021), a 400K object has about 8-22 Jupiter mass with an age of 1-10 Gyr. Ground- and space-based photometric observations (Cushing et al. 2011; Kirkpatrick et al. 2011) suggest that WISE1828 has an unusually red J - W2 color compared to other Y dwarfs. Atmospheric modeling analysis (e.g., Beichman et al. 2013; Cushing et al. 2021; Leggett et al. 2021) found that none of the atmospheric models can simultaneously explain the near- and mid-IR photometry and spectra. The discrepancy between the models and observations implies that WISE1828 could be a unresolved binary and/or important atmospheric processes are missing in the atmospheric models.

To understand the puzzling nature of WISE1828, we conduct a series of photometric and spectroscopic observations of WISE1828 under JWST GTO Program 1189 (P.I.: Tom Roellig). The broad wavelength coverage and superior sensitivity of JWST provide an unprecedented opportunity to peer deep into the cold Y-dwarf atmospheres, whose emission peaks at mid-infrared wavelengths. In my talk, I will present the JWST NIRSpec spectrum and NIRCam photometry of WISE1828. I will discuss the detected molecular absorption features and the preliminary modeling results on the atmospheric properties. I will discuss the single and binary scenario and the corresponding atmospheric structure of WISE1828.

Mitigating the impact of stellar photospheric heterogeneity on JWST exoplanet transmission spectra

Benjamin V. Rackham and Julien de Wit, Prajwal Niraula

The unprecedented coverage and precision offered by JWST has launched a new era of exoplanet characterization. Early Release Science results show conclusively the power of JWST to constrain the chemical compositions and physical structures of exoplanet atmospheres. However, while the ERS target WASP-39b was selected in part due to its quiet host star, which shows lower chromospheric activity than even the Sun, many exciting planets transit stars that are far more active. Unocculted spots and faculae on these stars imprint spectral signals in transmission spectra, which are even more evident now in the precise transmission spectra that JWST provides. Previous work has shown that our imperfect knowledge of stellar photospheres—particularly the emergent spectra of spots and faculae—limits our ability to correct for stellar photospheric heterogeneity. Here we show that our uncertainty with respect to the degree of stellar heterogeneity—namely the number of spectral components present on the projected stellar disk—presents another significant limitation. We find that properly marginalizing over possible photospheric compositions introduces an accuracy bottleneck for planetary atmospheric retrievals in systems with active host stars. We introduce a framework to account for impacts on precise transmission spectra due to the unknown complexity of stellar photospheric heterogeneity. We highlight avenues to better constrain photospheric complexity of exoplanet host stars during transit, including inferences from out-of-transit stellar spectra, TESS photometric variability, and high-resolution spectroscopy of activity indicators. Unlocking the full potential of transmission spectroscopy with JWST—particularly for small planets transiting small, active stars—will require leveraging these complementary approaches to inform our understanding of host-star photospheres.

The Chemistry of Planet Formation: A JWST-ALMA Survey of 2 Planet-Forming Disks

Carlos E. Munoz-Romero, Karin Öberg, Andrea Banzatti, Klaus Pontoppidan, Jane Huang, Ilse Cleeves, Charles Law, and Viviana Guzman

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 have now used MIRI to obtain the complementary chemical composition of the inner 10 au of 2/4 of these disks (AS 209 and HD 163296). We have begun assessing the chemical inventory of the small, terrestrial planet-forming regions, and have found hundreds of previously undetected CO, H2O, OH, C2H2, and H I lines, among others. Using LTE slab models and rotational diagrams, we have further obtained initial constraints on the column density and excitation conditions of select species. Together in synergy with ALMA observations, these provide chemical and dynamical links between disk regions, as well as the first radially complete C/N/O abundance ratio profiles in protoplanetary disks.

Molecular emission from protoplanetary disks: first results from the MINDS GTO program

E.F. van Dishoeck and MINDS team

The goal of the 120 hr MIRI Mid INfrared Disk Survey (MINDS) GTO program (Th. Henning, I. Kamp co-PIs) is to use JWST to (1) investigate the chemical inventory of the terrestrial planet forming zone, (2) to follow the gas evolution into the disk dispersal stage, and to (3) study the structure of protoplanetary and debris disks in the thermal mid-IR. The program builds a bridge between the chemical inventory of planet-forming disks and the properties of exoplanets. In total, about 50 targets (Herbig Ae stars, T Tauri stars, brown dwarfs and young debris disks) will be observed using MRS spectroscopy aiming at high S/N spectra covering the complete MIRI wavelength range. For a handful of selected targets also NIRSpec IFU high resolution spectroscopy will be taken.

At the conference, we will present the first analysis results of the MRS spectra of several T Tauri and Brown Dwarf disks. In addition to many lines from CO, H2O, CO2, C2H2 and HCN, also surprising new molecules in disks are identified. Together they point to a rich chemistry that is linked to the physical structure of the inner few au of these disks.

Coronagraphic Observations of the HR 8799 Planetary System

Geoffrey Bryden, Charles Beichman, Marie Ygouf, Jorge Llop-Sayson, Jens Kammerer, Marshall Perrin, Anthony Boccaletti, and Pierre-Olivier Lagage

Since its discovery in 2008, the iconic four-planet system HR 8799 has been studied intensively at wavelengths from 1 to 5 um, with photometry/spectroscopy constraining the planet atmospheres and astrometry tracing their orbits. While the orbits of the four planets are dynamically compact, additional planets could exist on stable orbits closer to or farther from the central star. In particular it has been suggested that an unseen planet is sculpting the debris disk edge at ~100 AU, with unknown mass and semi-major axis.

We report on NIRCam and MIRI coronagraphic observations of the system out to 15 um, both to observe the known planets at new wavelengths and to probe the outer gap (between HR 8799 b and the outer debris) for planet masses not previously detectable. As the only multi-planet system observed by JWST, the positions of the planets also provide a unique opportunity to triangulate the location of the parent star behind the coronagraphic mask, a key systematic uncertainty in coronagraphic observations.

Results from the JWST Solar System GTO Program

Heidi B. Hammel, Stefanie N. Milam, Leigh Fletcher, Dean Hines, Bryan Holler, Mike Kelley, Jonathan Lunine, Conor A. Nixon, Alex H. Parker, Andrew Rivkin, Naomi Rowe-Gurney, Pablo Santos-Sanz, John Stansberry, Cristina Thomas, Matt Tiscareno, Samantha Trumbo, Geronimo Villanueva, Ian Wong, and JWST Team Solar System

The Solar System Guaranteed Time Observations (GTO, originally proposed by H. B. Hammel in 2002 as part of her application for the role of JWST Interdisciplinary Scientist) represent a suite of observations that demonstrate the capabilities of James Webb Space Telescope within our local neighborhood. With GTO observations ranging from near-by asteroids out to the most distant reaches of our planetary system, the program complements existing in situ missions, and helps prepare for future missions. Some results for the Solar System GTO program are presented in other talks in this session, but more observations have been taken. This presentation will highlight successful observations not covered elsewhere in the session, and also briefly outline the Solar System GTO science remaining to be done in Cycle 1. Most of the Solar System GTO observations are immediately available to the planetary community with no proprietary period, in order to facilitate proposal planning for Solar System observations in Cycle 2. The results to date from this GTO program demonstrate the exceptional capabilities of JWST to advance research within our Solar System. We thank all who helped enable the moving target tracking and bright object observations that make these results possible.

Complex structures in Jupiter's low-latitude ionosphere as revealed by JWST NIRSpec

Henrik Melin, Tom S. Stallard, Leigh N. Fletcher, Mike T. Roman, Jake Harkett, Imke de Pater, Thierry Fouchet, Michael H. Wong, Patrick Fry, Ricardo Hueso, Mark Showalter, Dominique Bockelée-Morvan, Emmanuel Lellouch, Katherine de Kleer, Al Conrad, John Stansberry, Bryan Holler, and the Jovian ERS team

In late July 2022, a JWST NIRSpec mosaic was acquired at Jupiter's Great Red Spot (GRS) as part of the Early Release Science observations of the Jovian system (#1373). This is a rich data-set that contains solar scattering of aerosols, absorptions by phosphine and ammonia, as well as other minor species in the atmosphere. In the 3-4 micron range, we also capture emissions from the molecular ion H_3^+, a dominant species in the charged particle ionosphere which sits in the upper atmosphere. Once produced, H_3^+ thermalises with the surrounding neutral atmosphere, and the intensity of emission is driven linearly with density and exponentially with temperature. By analysing the H_3^+ spectrum we can disentangle the two drivers, and explore in detail the physical properties of the ionosphere and upper atmosphere. H_3^+ is produced by both solar EUV ionisation across the illuminated disk, and by auroral charged particle impact ionisation about the magnetic poles. Since the GRS is well separated from the auroral regions, we expect the dominant production source to be the uniform illumination by the Sun, and we could therefore assume a relatively smooth distribution of H_3^+. However, the NIRSpec observations reveal something very unexpected. The ionospheric H_3^+ emissions are rich in features with continuous dark bands running across the mosaic, some even appearing to have right-angles in them. These JWST observations strikingly unveils the largely unexplored low-latitude ionosphere, before often thought of as rather boring, as complex, with intricate patterns, and ultimately, a region that is very poorly understood. In this presentation, we explore the mechanisms that can produce this these intriguing patterns, and what that tells us about the physics of Jupiter's ionosphere and upper atmosphere.

First NIR spectra of a Debris Disk with JWST

Isabel Rebollido, Christine Chen, Marshall Perrin, Cicero Lu, John Debes, Amaya Moro-Martin, Aki Roberge, and Kadin Worthen

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 (mostly CO), 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 exocomets 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. This mechanism, if proved, could have implications on the origin of water on Earth. I present here the first spectra of a debris disk obtained with NIRSpec Fixed Slit in the 3 to 5 micron range at R ~ 2,700 to look for volatiles. This object, HD 36546, is part of a sample of 5 objects with observations scheduled to be completed by early fall 2023.

NIRCam GTO Direct Imaging of YSOs

Jarron Leisenring, Gabriele Cugno, Ruobing Dong, Alexandra Greenbaum, Tom Greene, Doug Johnstone, Michael Meyer, Camryn Mullin, Kevin Wagner, and Schuyler Wolff

Observations in both scattered light (e.g., GPI and SPHERE) and thermal emission (e.g., ALMA) have revealed gaps and spiral structures within circumstellar disks. Dynamical interactions of the disk with massive protoplanets can readily explain the presence of these disk substructures. Direct observations of these protoplanets will test theories of planet formation by characterizing them in terms of i) temperature, luminosity, and orbital location, ii) nature of any circumplanetary disks and its accretion, and iii) local physical conditions of the circumstellar disk.

As part of the NIRCam GTO program (PID 1179), we are searching for protoplanets embedded within the circumstellar disks of nearby young stars that show strong evidence of companion-induced morphologies, including spiral arm structures (SAO~206462 and MWC~758), multiple ringed substructures in both thermal emission and scattered light (TW~Hya and HL~Tau), and known protoplanets (PDS 70).

Of the five targets, MWC 758 and HL Tau were observed in October. To attain the necessary inner working angle, these observations were performed in direct imaging mode (sans coronagraph) using the F187N, F200W, F405N, and F410M filters. We will present preliminary results for these two sources, including constraints on potential companions, disk features, discussion on technical challenges, and comparison to pre-flight performance expectations.

Analysis of JWST transit observations with the Tiberius Pipeline

Jea Adams, James Kirk, Mercedes López-Morales, and Alexander Rathcke

We present the analysis of Trappist-1c and WASP-39b JWST transit observations with the Tiberius Pipeline. The Trappist-1c transit was observed as part of Cycle 1 program GO-2420 with NIRSpec PRISM; the WASP-39b transit was observed with NIRSpec G-395H as part of the Transiting Exoplanet Community Early Science Release program GO-1366. We describe the steps we follow with Tiberius, from stage 1 JWST data products to fitted transmission spectra, and show the resulting spectra for each target.

Of the five targets, MWC 758 and HL Tau were observed in October. To attain the necessary inner working angle, these observations were performed in direct imaging mode (sans coronagraph) using the F187N, F200W, F405N, and F410M filters. We will present preliminary results for these two sources, including constraints on potential companions, disk features, discussion on technical challenges, and comparison to pre-flight performance expectations.

Eureka!: An End-to-End Pipeline for JWST Time-Series Observations

Jonathan Brande, Taylor J. Bell, Eva-Maria Ahrer, Aarynn L. Carter, Adina D. Feinstein, Giannina Guzman Caloca, Megan Mansfield, Sebastian Zieba, Caroline Piaulet, Björn Benneke, Joseph Filippazzo, Erin M. May, Pierre-Alexis Roy, Laura Kreidberg, and Kevin B. Stevenson

The advent of JWST science operations pushes the field of exoplanet time-series observations and spectroscopy into a new era of sensitivity, precision, and spectral resolution. These new data need new analysis tools to fully exploit their unprecedented information content. To enable the scientific community to quickly, efficiently, and accurately analyze JWST time-series exoplanet observations, we present the new Python package Eureka!. In this presentation, we describe the Eureka! pipeline, starting with raw, uncalibrated FITS files and ultimately yielding precise exoplanet transmission and/or emission spectra. Eureka! is modular, allowing each of the six calibration, reduction, and analysis stages to be run independently or together, controlled by easily-modified input files. Eureka! provides ample information about the outputs of each stage, as well as diagnostic plots allowing for easy comparison of Eureka! results with independent analyses. Eureka! has been optimized for exoplanet-specific observations, but the core functionality could be reused for JWST time-series observations in other research areas. Eureka! has been thoroughly tested and has already contributed to high-impact JWST science as part of the Transiting Exoplanet Community Early Release Science program, and will continue to be a major exoplanet community analysis tool enabling efficient and accurate exoplanetary science results during JWST's main mission.

JWST-MIRI spectrum of post-outburst chemistry in planet-forming regions

Lindsey Diehl

EX Lupi is a pre-main-sequence star with a protoplanetary disk that exhibits periodic accretion bursts, the prototype of a class of outbursts called “EX-Ori” that are scaled-down versions of “FU-Ori” outbursts. These accretion events are possibly common to all stars early in their formation, and their effects on circumstellar material may be fundamental for the properties of the emerging planetary system. During a recent outburst in 2008, EX Lupi has been extensively studied across wavelengths with multiple instruments, finding that outbursts may have strong effects in forming dust crystals similar to those found on comets, as well as in dissociating water and organic molecules in the planet-forming region. After being quiet for several years, EX Lupi had another weaker outburst in 2022 and a new spectrum was taken with MIRI MRS in August. In this work, we will present the analysis of molecular line spectra detected with MIRI, and what we are learning on the impact of accretion outbursts on the chemistry of planet-forming regions from comparison to the pre-outburst and during-outburst molecular spectra taken before with other instruments.

Spinning Phase Reference Calibration Data into Gold: Finding Planetary Mass Companions to Bright Stars without Reference Star Observations

Matthew De Furio, Marie Ygouf, Graça Rocha, Alexandra Greenbaum, Michael R. Meyer, and Charles Beichman

The James Webb Space Telescope (JWST) is orders of magnitude more sensitive than any other facility across the near to mid-infrared wavelengths. Many approved Cycle 1 programs take advantage of its highly stable point spread function (PSF) to directly detect faint companions using diverse high-contrast imaging (HCI) techniques: coronagraphy, aperture masking interferometry (AMI), roll subtraction, and reference star PSF subtraction. However, primary mirror segments experience thermal drifts which require periodic re-phasing. Many programs utilize observations of a reference star to remove the stellar contribution within an image which can typically take half of the total allocated time. We present a high-contrast imaging technique using the measured wavefront error (WFE) from a phase calibration observation (performed roughly every 48 hours) as prior information to estimate the WFE of a given observation and simultaneously search for faint companions, without using a calibrator star. We model the wavefront with three low order Zernike coefficients per mirror segment, using the Hexike basis. We determine the most likely WFE and astrophysical scene by generating synthetic reference PSFs from the Hexike coefficients and comparing to the data. Our technique has proven effective on simulations of NIRISS full aperture and AMI imaging. We describe the results of our technique applied to the publicly available data, and compare its performance to other post-processing techniques. With this approach, significant amounts of observing time can be saved in most HCI observing modes.

39P/Oterma: The First Centaur Seen by JWST

Olga Harrington Pinto

Centaurs are minor solar system bodies transitioning from Scattered Disk orbits in the Kuiper Belt region to those of Jupiter Family comets. Having spent far less time close to the Sun than the more evolved Jupiter Family Comets, they can serve as powerful tools for tracing primitive material from the formation of the Solar System. Their orbits are likely too far from the Sun for sublimation of water ice to be a significant driver of their activity, although crystallization of amorphous water ice may play a role, and more volatile species like CO2 and CO are more easily sublimated at temperatures experienced by Centaurs. However, a lack of molecular detections in Centaurs limits our understanding of their composition and activity. At last, JWST gives us the first opportunity to measure the volatile content in many of these distant bodies before they are significantly processed by the Sun, and so JWST lets us address this key question about the composition of the icy planetesimals from the era of planet formation. For example, the relative CO, CO2, and H2O content of icy small bodies can give clues about the conditions in the protoplanetary disk. 39P/Oterma is an occasionally active Centaur whose orbit changes substantially over decades due to gravitational perturbations from Jupiter. 39P was observed on July 27, 2022, while 5.82 au from the Sun with the JWST NIRSpec instrument. NIRSpec operates over a wavelength range of 0.6 to 5 microns, which covers emission features from CO, CO2, and H2O (the main candidates for drivers of Centaur activity), as well as water ice absorptions. Preliminary results on 39P's volatile content will be presented and discussed.

JWST Reconnaissance Transmission Spectroscopy of the Earth-sized Exoplanet TRAPPIST-1 b

Olivia Lim, René Doyon, Björn Benneke, Etienne Artigau, Louis-Philippe Coulombe, Michael Radica, Loïc Albert, Caroline Piaulet, Pierre-Alexis Roy, Salma Salhi, David Lafrenière, Nicolas Cowan, Jason Rowe, Néstor Espinoza, Jake Taylor, and Antoine Darveau-Bernier

TRAPPIST-1 is a nearby exoplanetary system consisting of seven rocky, Earth-sized exoplanets transiting a nearby Jupiter-sized M8 dwarf host star. Each TRAPPIST-1 planet was previously observed and cloud-free hydrogen-rich atmospheres were confidently rejected on all seven of them. However, to date, published observations could not inform on the presence of secondary atmospheres dominated by gases such as CO2, H2O, or N2. In this talk, we present the first high-precision transit spectra of the warm Earth-sized planet TRAPPIST-1 b based on two transit observations using NIRISS in SOSS mode on the James Webb Space Telescope. TRAPPIST-1 b is the most favorable Earth-sized planet for characterization via transmission spectroscopy among all exoplanets. As such, our observations have the sensitivity to detect a wide range of atmospheres, providing unprecedented insight into the potentially secondary atmosphere on a rocky Earth-sized planet outside the solar system.

Evidence of temperature and composition disturbance induced by auroral precipitation from Jupiter MIRI/MRS Observations

Pablo Rodriguez-Ovalle, Thierry Fouchet, Jake Harkett, Henrik Melin, Leigh Fletcher, Pat Fry, Emmanuel Lellouch, Dominique Bockelee, Manuel Lopez-Puertas, Imke de Pater, Mike Roman, Mike Wong, Patrick Irwin and the ERS 1373 team

JWST performed several observations of Jupiter last summer, most of them as part of the Early Release Science program 1373 (ERS-1373). Along with these observations, a complementary observation with MIRI MRS was carried out during the commissioning phase using band A of the four MRS channel. This observation was aimed at the south polar region of Jupiter, allowing us to obtain sufficient spectral and spatial information, to map stratospheric temperature and hydrocarbons abundances.

Since these observations were part of the commissioning program, they included only sub-band A of each channel. Nevertheless, this spectral range allows us to study the troposphere and the stratosphere of Jupiter simultaneously. Notably, we were able to measure stratospheric temperatures at pressures between 10 and 0.1 mbar and map the homopause height. To do so, we first needed to retrieve the homopause height (which determines the methane vertical profile of Jupiter) by a simultaneous analysis of fourteen different models of the atmosphere. We found that the auroral oval leaves an imprint in the stratosphere, creating a warmer region where the auroral oval can be spotted in the UV and IR. The analysis also shows an upwards displacement of the homopause level in the auroral oval, in agreement with previous studies but with a much better spatial resolution.

We will also present a 3D map of the acetylene volume mixing ratio, and its relation to the auroral activity.

Comet 22P/Kopff as observed by JWST: Investigation of the chemical and spatial heterogeneity of the gas and dust coma

Silvia Protopapa, M. S. P. Kelley, I. Wong, C. E. Woodward, S. N. Milam, and H. B. Hammel

Cometary nuclei are the remnants of planetesimal formation in the giant planet region of our solar system. They formed cold and have remained cold over the history of the solar system, cold enough to retain ices much more volatile than water (e.g., CO, CH_3OH, CO_2 ices). However, their nucleus surfaces are affected by solar heating and can evolve over repeated perihelion passages. Thus, making compositional links between cometary surfaces and the protoplanetary disk requires an understanding of their present-day evolution. JWST NIRSpec integral field unit (IFU) observations (prism mode) of the Jupiter-family comet (JFC) 22P/Kopff were successfully acquired on Aug 25, 2022 (PID 1252) when the comet was at 2.2 AU from the Sun. While the comet nucleus is on the edge of the detector in all four dither positions, these observations enable the chemical and spatial characterization of a portion of the cometary coma over the wavelength range 0.6–5.3 micron. The extracted spectra display clear emission bands from H_2O vapor at 2.7 micron, CO_2 at 4.3 micron, and organics in the 3.3–3.5 micron region. Less prominent emission features due to minor species are also present in the spectra and their nature is currently under investigation. The underlying continuum provides information on the properties of the dust (ice and refractories) in the coma. The level of details revealed by these observations is only comparable to those acquired from spacecraft missions for only three JFCs: 9P/Tempel 1, 67P/Churyumov-Gerasimenko, and 103P/Hartley 2. We will present our preliminary results for 22P/Kopff in the context of spacecraft observations, shedding light on the heterogeneity of the primary ices near the comet surface that provides insights into nuclear surface evolution. We will also present 3D maps of the C_2H_2 and C_2H_6 volume mixing ratios.

First Observations of Titan with the James Webb Space Telescope

Conor A. Nixon

As the only moon in the solar system with a substantial atmosphere, Titan is a tantalizing target that presents many scientific puzzles, yet difficult to study due to its distance. The Cassini-Huygens mission at Saturn (2004-2017) for the first-time revealed Titan as a complex, Earth-like world with river valleys, hydrocarbon lakes and seas, vast dune fields made of organic particles, and icy mountains. The commissioning of the James Webb Space Telescope (JWST) in 2022 is a watershed moment for planetary astronomy, providing a new and powerful tool for imaging and spectroscopy at wavelengths from 0.6 to 25 microns, a key part of the infrared spectrum where the thermal emissions from the outer planets are strongest. In October or November 2022, JWST is scheduled to observe Titan in the near-infrared as part of the Guaranteed Time Observations (GTO) program for solar system science. The observations will use two of JWST's instruments– NIRCam for filter imaging, and NIRSpec for hyperspectral imaging. These observations will provide important new data on the composition, chemistry and dynamics of Titan's atmosphere and surface, and fill in gaps in knowledge of its seasonal cycle. In this presentation, we will show early results from these observations, and preview the expected science return from later detailed analysis.

A JWST NIRCam Coronagraphic Imaging Survey of Nearby Young M Dwarfs

Joshua Schlieder & JWST GTO 1184 Team

Cometary nuclei are the remnants of planetesimal formation in the giant planet region of our solar system. They formed cold and have remained cold over the history of the solar system, cold enough to retain ices much more volatile than water (e.g., CO, CH3OH, CO2 ices). However, their nucleus surfaces are affected by solar heating and can evolve over repeated perihelion passages. Thus, making compositional links between cometary surfaces and the protoplanetary disk requires an understanding of their present-day evolution. JWST NIRSpec integral field unit (IFU) observations (prism mode) of the Jupiter-family comet (JFC) 22P/Kopff were successfully acquired on Aug 25, 2022 (PID 1252) when the comet was at 2.2 AU from the Sun. While the comet nucleus is on the edge of the detector in all four dither positions, these observations enable the chemical and spatial characterization of a portion of the cometary coma over the wavelength range 0.6–5.3 micron. The extracted spectra display clear emission bands from H2O vapor at 2.7 micron, CO2 at 4.3 micron, and organics in the 3.3–3.5 micron region. Less prominent emission features due to minor species are also present in the spectra and their nature is currently under investigation. The underlying continuum provides information on the properties of the dust (ice and refractories) in the coma. The level of details revealed by these observations is only comparable to those acquired from spacecraft missions for only three JFCs: 9P/Tempel 1, 67P/Churyumov-Gerasimenko, and 103P/Hartley 2. We will present our preliminary results for 22P/Kopff in the context of spacecraft observations, shedding light on the heterogeneity of the primary ices near the comet surface that provides insights into nuclear surface evolution.We will also present 3D maps of the C2H2 and C2H6 volume mixing ratios.

Star Formation & Stellar Populations (Resolved star formation, interstellar medium, galactic recycling)

Early Imaging Results with JWST/NIRCam: Dusty Star Demographics and Evolutionary Characteristics of Massive Star-Forming Regions in NGC 6822

Alec S. Hirschauer, Laura Lenkić, Olivia Jones, Margaret Meixner, Tea Temim, B. A. Sargent, Martha Boyer, Omnarayani Nayak, Conor Nally, and Nolan Habel

We present James Webb Space Telescope (JWST) photometric data from a guaranteed time observational (GTO) program of the metal-poor star-forming dwarf galaxy NGC 6822 (Barnard's Galaxy). This isolated system is nearby (~490 kpc) and shares similarities in structure and abundance ([Fe/H] ~ -1.2; Z ~ 30% $Z_\odot$) with the Small Magellanic Cloud (SMC). As the earliest generations of stars were produced in galaxies at high redshift, where physical conditions varied drastically from what is observed locally today, nearby low-metallicity systems represent our best accessible analogs from which to comprehend the lifecycle of dust and metals in the early Universe. In particular, in order to more fully understand the role of dust in metal-poor environments, it is critically important to robustly identify their evolved, dust-producing asymptotic giant branch (AGB) stars. Utilizing NIRCam imaging in four filters (F115W, F200W, F356W, and F444W), we showcase processing techniques for early NIRCam data and present our initial source list of dusty and evolved stars within the central stellar bar, as well as for two massive star-forming regions (Hubble IV and the recently-discovered Spitzer I), which appear to manifest different evolutionary stages. Employing new color-magnitude diagram (CMD) and color-color diagram (CCD) analyses, we explore the demographics of oxygen- and carbon-rich AGB stars and identify dust-enshrouded young stellar objects (YSOs). Our program goals aim to investigate in what manner star-formation mechanisms have changed since the epoch of early-Universe abundance levels, as well as to understand how these high-redshift systems produced significant quantities of dust without the necessary elapsed time for AGB stars to evolve and contribute via mass loss.

Delving for Dwarfs: How to Identify Milky Way Brown Dwarfs in CEERS

Benne W. Holwerda and CEERS

Low mass (sub)stellar objects are an interloper population in the dropout search for high-redshift galaxies. Alternatively, they represent the lower end of the initial mass function and the transition to free-floating planets belonging to the Milky Way. Identifying these objects in deep NIRcam extragalactic imaging is a priority for both kinds of science. Without resorting to additional information (proper motion from multiple epochs, spectroscopy), can these objects be identified in and typed with the extragalactic choice of filters.

JWST/NIRcam has several advantages over HST/WFC3 NIR imaging: more filters in the IR and especially the longer wavelength filters which are known to correlate with stellar type. However, star/galaxy separation has proven challenging using the HST approaches because of the more complicated PSF of JWST.

Here I present initial work to identify brown dwarfs using the Cosmic Evolution Early Release Science Survey (CEERS) NIRcam campaign. We use kNN nearest neighbor machine learning to identify and type these sources with the four filters (F115W, F150W, F200W, F277W). The training set is artificial photometry based on iSPEX spectra of nearby brown dwarfs. Brown dwarfs are subtyped in 10 subtypes each (M0-M9, L0-L9 etc). The result of the kNN is a good classification within half a type: M0-M5 from M6-M9 etc can be achieved with ~95% precision and recall. More granular typing suffers from worse metrics.

Initial results on the first four CEERS NIRcam exposures show that the long wavelengths of NIRcam (F356W an F444W) are necessary for final confirmation of type. This looks to be a viable way to identify brown dwarfs in NIRcam data for Milky Way science (scale of the Milky Way, total number of brown dwarfs in disk and halo, total number of brown dwarfs, and the galaxy-wide IMF).

Near infrared insights into dense star formation in the galactic massive star forming region NGC3603.

Ciaran Rogers, Guido de Marchi, Bernhard Brandl, Giovanna Giardino, and Pierre Ferruit

High resolution spectra (R = 2700) from 100 main sequence and pre-main sequence stars in the massive star forming region NGC3603 have been obtained using the multi-object spectroscopy mode (MOS) of James Webb Space Telescope's (JWST) Near InfraRed Spectrograph (NIRSpec). These recently obtained, first of their kind observations offer high signal-to-noise near infrared (NIR) spectra of still forming pre-main sequence stars, with prominent resolved emission lines, indicative of active accretion. Careful data reduction and background subtraction has enabled us to accurately remove contaminant nebular emission, allowing for the reliable measurement of stellar hydrogen recombination lines, including many lines that are not visible from ground based observations. These lines will provide us with numerical estimates of crucial star formation processes, such as accretion luminosity and mass accretion rate. In a number of pre-main sequence stars, CO bandheads are also detected, both in emission and absorption. These lines provide a separate, independent estimate of accretion processes. The aim of this study is to both present these 100 high quality spectra as a new catalogue for other astronomers, as well as to gain insight into star formation processes with this new dataset.

StarbugII - A JWST PSF photometry tool optimised for complex crowded fields

Conor Nally, Olivia Jones, Alec Hirschauer, and Margaret Meixner

The stunning high-resolution images from JWST are often dominated by complex backgrounds and diffuse emissions from interstellar dust. In these complex regions source detection and photometry can pose significant challenges for which many established tools developed for optical and/or ground-based observatories were not designed to handle. Additionally, we now see our stellar surveys littered with background galaxies and a myriad of faint sources that were previously lost to background noise. This unprecedented depth and sensitivity require our photometry tools to be optimised for these complex fields.

StarBugII is a new photometry tool written around an astropy-photutils core, optimised for the NIRCam and MIRI images from JWST. It contains a suite of routines with tunable parameters and a simple interface. Using an ensemble of background subtraction techniques, StarBug detects the sources in a range of environments and removes likely non-stellar objects. The source list can be used as is or improved with background estimation and PSF photometry and artificial star testing. The code accommodates catalogue matching between exposures, JWST pipeline calibration stages, filter bands and imaging instruments.

We have used these tools on JWST data of NGC346 and NGC 6822 recovering upwards of 10 times the number of sources that the JWST stage three pipeline does.

Mapping protostellar outflows with JWST: First results of NIRSpec IFU observations towards TMC1A

Jon Ramsey, Daniel Harsono, Zhi-Yun Li, Per Bjerkeli, Klaus Pontoppidan, Korash Assani, Adele Plunkett, Hannah Calcutt, Lars Kristensen, and Jes Jorgensen

Outflows from young stars are ubiquitous in regions of star formation. Indeed, it turns out they are a natural consequence of star and disk formation in the presence of magnetic fields. It then makes sense to ask about the why, where, and when of outflows, their properties, and how they function. Although the why is now well understood, i.e., they efficiently remove angular momentum, and the where and when are now reasonably well-constrained by observations, measuring and understanding the conditions where the outflow is launched remains challenging. While the Atacama Large Millimeter/submillimeter Array (ALMA) has done an excellent job of observing cool molecular gas down to au scales in outflowing sources, much less is known about the high (> 1000 K) temperature gas in very young sources at high spatial and spectral resolution. I will present preliminary results from JWST-NIRSpec IFU observations towards the Class I protostellar system TMC1A that reveal a rich collection of emission lines tracing the hot gas, including several atomic Hydrogen lines, in the outflow and near the disk. I will also discuss how the NIRSpec data is helping us place constraints on the properties at the base of TMC1A outflow, and what this means for our overall understanding of protostellar outflows.

Physical Conditions of the Molecular Gas in the SMC's Star Forming Region NGC 346

Laura Lenkić, Margaret Meixner, Molly Finn, Tony Wong, Katia Biazzo, Tracy Beck, Bernhard Brandl, Laurie Chu, Katja Fahrion, Giovanna Giardino, Nolan Habel, Alec Hirschauer, Tereza Jerabkova, Olivia Jones, Charles Keyes, Guido De Marchi, James Muzerolle, Conor Nally, Omnarayani Nayak, Catarina Alves de Oliveira, Nino Panagia, Klaus Pontoppidan, Massimo Robberto, Ciaran Rogers, Elena Sabbi, Beth Sargent, David Soderblom, and Peter Zeidler

The brightest star forming region in the Small Magellanic Cloud (SMC), NGC 346, is host to roughly 100 young stellar object (YSO) candidates, thousands of pre-main sequence stars, and more than 30 OB stars which are major sources of ionization and feedback in this region. Using ~0.5 pc scale ALMA observations of 12CO(1-0), 12CO(2-1), and 13CO(2-1), we characterize the properties of molecular gas (H2) clumps we identify in NGC 346 using the astrodendro package and investigate the impact of the presence of YSOs. We derive the sizes, linewidths, and molecular gas masses from 12CO(1-0) and a CO-to-H2 conversion factor and 13CO(2-1) assuming local thermal equilibrium (LTE). This allows us to derive the size-linewidth relation and to investigate the boundedness of the molecular gas structures for each CO line. Our results show elevated linewidths for a given size and less bound structures in 12CO(1-0) compared to 12CO(2-1) and 13CO(2-1). In addition, we use the non-LTE code RADEX to model the observed line intensities and constrain the H2 densities, temperatures, and CO column densities of each structure we identify in this region. We will present the results of this modeling and discuss the implications of our results. Finally, a James Webb Space Telescope survey of NGC 346 allows us to study the correlation between the molecular gas and infrared emission originating from, for example, polycyclic aromatic hydrocarbons, and we will present preliminary results highlighting this.

High Spatial Resolution JWST/NIRCam Extinction Map of Bok Globule B68

Laurie E. U. Chu, Klaus Hodapp, Fengwu Sun, JWST Star and Planet Formation NIRCam and GTO Team

Observations of dust in dense molecular cloud cores at the earliest stages of star formation trace the physical conditions required for grain growth and the relation to ice mantle formation. Dust extinction maps of dense cloud cores also constrain initial protostellar cloud collapse. The Bok globule Barnard 68 (B68) has been an exquisite test bed to study the low-mass quiescent core phase preceding star formation. Previous extinction maps of B68 were made by observing ~1000 lines of sight toward background stars from 1.25 – 2.16 microns (Alves, Lada, & Lada 2001). This has remained one of the deepest, and highest spatial resolution extinction maps of a dense core until now. JWST observations (GTO #1187) cover B68 with 8 wide filters and 1 medium filter from 0.7 – 4.4 microns with NIRCam. At the longest wavelength filters there are >10,000 background stars seen through the core. We match stars across the filters and apply the NICER algorithm (Lombardi & Alves 2001) to derive the extinction using photometry from multiple (3 or more) photometric bands. After applying a smoothing function we produce the highest spatial resolution extinction map to date unveiling small-scale structures and allowing us to peer into the densest parts of the core to investigate the pre-stellar core phase. We will also summarize upcoming analysis mapping ices in B68 using the NIRCam Wide Field Slitless Spectroscopy (WFSS) mode.

GLASS- JWST-BD1: A Faint, Distant, and Cold Brown Dwarf

Mario Nonino and GLASS-ERS-Team

A significant fraction of Milky Way stars near the Sun are cool brown dwarfs, nonfusing stars that have masses <0.1M_Sun, effective temperatures T_eff below 2000K, and are classified as late-L, T, and Y dwarfs.

These objects are intrinsically faint and emit primarily at infrared wavelengths.

The JWST's unprecedented imaging and spectroscopic capabilities represent a major step forward in the detection of cool and distant brown dwarfs, providing orders of magnitude greater sensitivity than Spitzer, particularly in the 3–5 µm wavelength range where cold brown dwarf spectral energy distributions peak.

In this poster we present the serendipitous discovery and the analysis of GLASS-JWST-BD1, a T dwarf candidate in the GLASS-ERS Abell 2744 field.

GLASS-JWST-BD1 is the first JWST faint, and likely thick disk or halo T type brown dwarf selected. It underscores the unique power of JWST to probe the very low-mass end of the substellar mass function in the Galactic thick disk and halo.

Spatially resolved extinction in NGC 3324 from star counts in JWST images

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We have calculated the spatially resolved extinction from star counts using the publicly available JWST Early Release Observations of the NGC 3324 nebula. The large number of point sources seen in these images allows us to obtain extinction maps with a relatively high, ∼ 30′′ angular resolution. We find that the molecular region of the observed field has two dense clouds, with masses of M = (95±7)M⨀ within projected areas of ≈ 1 pc2 . Therefore, these clouds are likely to be localized low mass star formation regions.

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Probing ice chemistry in a low-mass star-forming region with the Ice Age program: First results from MIRI Low Resolution Spectroscopy

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Icy grain mantles are the main reservoir for volatile elements in star-forming regions across the Universe, as well as the formation site of pre-biotic complex organic molecules (COMs) seen in our Solar System. The Ice Age program (DD-ERS 1309, PI: M. McClure) aims at tracing the evolution of pristine and complex ice chemistry in a representative low-mass star-forming region through observations of a: pre-stellar core, Class 0 protostar, Class I protostar, and protoplanetary disk. This region is located in the Chameleon I molecular cloud complex and is being observed with MIRI, NIRSpec, and NIRCam, covering wavelengths from 3 to 15 microns at low and high resolutions. Here, we focus on the transmission spectra of two fields illuminated by a background star that were observed with MIRI Low Resolution Spectroscopy (LRS). We present the data reduction including our contribution to improving the LRS wavelength calibration and the quality of the spectra, and discuss the first scientific outcomes. These spectra show broad absorption features that reveal the molecular composition of ices and silicates. The combination of MIRI LRS with near-infrared spectra from NIRSpec and NIRCam provides a wealth of information on the chemistry of this star forming region.

High-Resolution Imaging of Extragalactic Young Stellar Objects in NGC 346 with NIRCam

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We present multi-band near-infrared (IR) JWST imaging of Spitzer-identified Young Stellar Objects (YSOs) in the Small Magellanic Cloud (SMC) star-forming region, NGC 346. To date, detailed imaging at sub-parsec scales of extragalactic YSOs has been impossible, as the dusty, extinguished protostellar envelopes do not generally extend beyond 10,000 AU. With JWST's NIRCam, we image YSO candidates within NGC 346 with unprecedented resolution: down to ~5000AU scales across six filters from 1.15 to 4.44 microns. Here we showcase a selection of interesting YSO sources and compare these new observations with existing Spitzer near-infrared imaging. Our new observations show evidence of jets generated by ongoing accretion. Previously, only two examples of jets in this region were known. With JWST's unprecedented resolution in the near-IR, we expand this sample and show that the detection of jets toward YSOs in this region is common. We demonstrate the utility of this resolved imaging in disentangling cool, IR-emitting YSOs from reddened background galaxies. Because of the SMC's relatively nearby proximity as well as the dwarf galaxy's low metallicity, these observations offer an unprecedentedly detailed window into extragalactic star formation, and in particular, into star formation in an environment analogous to the low-metallicity early universe.

Excitation and Extinction in 30 Doradus

Remy Indebetouw

We present preliminary analysis of early release JWST imaging and spectral cubes in 30 Doradus, specifically of the molecular and atomic Hydrogen emission lines. The many lines observed with MIRI/MRS and NIRSPEC/IFU, along with the excellent state of the MIRI data, enable analysis of the mid-infrared extinction from H recombination lines, and the excitation state of molecular hydrogen. The MIR extinction curve is flat, similar to seen in other environments. Molecular Hydrogen is warm and generally consistent with shock excitation despite significant irradiation from nearby R136.

Serendipitous detection of SN 1980K with JWST/MIRI

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The type II-L supernova SN 1980K is located in the close 'SN factory' galaxy NGC 6946 (D~7Mpc). Due to its fortunate location and evolutionary stage, 1980K serves as a promising candidate for studying the transitional phase between young SNe and older SN remnants. Moreover, SN 1980K also provides a great opportunity to investigate the physical properties in the close environments of SNe: previously, both late-time optical and infrared emission was reported on the SN, for which scattered light echoes from circumstellar dust was given as a viable explanation.

During the first round of observations of our program Cycle 1 GO 2666, SN 1980K was serendipitously captured on JWST/MIRI images taken on the field of SN 2004et in the same galaxy. Despite its current age of more than 40 years, SN 1980K can be identified as a clear and bright point source in all 7 filters (from F560W up to F2550W).

We report the results of analysis of mid-IR spectral energy distribution (SED) based on both aperture and PSF photometry carried out on the JWST dataset of the SN. An unexpected result is the presence of a relatively large amount (~0.002 solar masses) of warm (T~150K) dust. In order to investigate the mid-IR SED in detail, we fit both analytical and numerical dust models and draw conclusions on the dust parameters and on the possible channels of its origin. Furthermore, we additionally involve previously published mid-IR (Spitzer/IRAC and MIPS) and late-time optical data in our analysis, in order to present a truly comprehensive study on SN 1980K.

Star-forming Regions in the Starburst Ring of NGC 7469

Thomas Bohn and GOALS Team

Identifying and characterizing star-forming regions in extreme star-forming galaxies is important to understanding how galaxies and stellar bodies are formed. The newly formed stars in these regions, however, are typically enshrouded within clouds of gas and dust, and thus can be missed by UV-optical observations. The high spatial resolution and sensitivity of JWST has enabled us to analyze these embedded regions with unprecedented detail. In this talk, we present JWST NIRCam (F150W, F200W, F335M, and F444W) and MIRI (F560W, F770W, and F1500W) imaging of NGC 7469; a unique galaxy that hosts a circumnuclear starburst ring with a central AGN. With NIRCam, we identify 65 star-forming regions within the ring, more than doubling the number of sources previously identified by HST. By comparing stellar population models to the colors of these sources, we find 19 sources with red near-infrared colors suggesting they are young (< 5 Myr), embedded (A_V > 7), and surrounded by diffuse hot dust emission. This discovery increases the number of young sources identified by a factor of four, and raises the total percentage of the young sources to almost 40% of the total source detections in the ring. We also detect seven regions of significant mid-infrared emission that account for roughly 40% of the total luminosity of the ring at 5.6um. The majority of the star-forming regions identified in the near-infrared fall within these regions indicating that with JWST we are discovering a large number of heavily obscured sources missed by previous observations. These results showcase the power of JWST to detect and characterize embedded sources at sub-kiloparsec scales.

Multiple stellar populations in Globular Clusters: exploring the low mass regime

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The HST has shown that nearly all Globular clusters (GCs) host multiple stellar populations. The origin of this phenomenon is still under debate: most scenarios suggest that the ancient GCs had multiple bursts of star formation that provided a significant contribution to the assembly of the Galactic halo and the cosmic reionization. As an alternative, all GC stars are coeval and multiple populations are the consequence of the accretion of polluted material onto existing stars. Nearly all HST results are based on UV photometry, which provides most of the information on multiple populations. Due to the limits of the UV detectors, the available studies are focused on giant stars and bright main-sequence stars, while the low-mass regime is nearly unexplored. In this work, we present simulated NIRCam photometry of GC stars that accounts for the chemical composition of the multiple populations. We confirm previous conclusions that NIRCam photometry is poorly sensitive to multiple populations among giant stars and bright main-sequence stars. On the contrary, we find that photometric diagrams built with appropriate NIRCam filters are outstanding tools to identify and characterize the multiple populations among M-dwarfs. We show that the comparison between the properties of multiple populations among very low-mass stars, as inferred from JWST, and those on more-massive stars from HST allow us to discriminate the formation scenarios. Finally, we compare our simulations with preliminary photometric diagrams that we obtained from NIRCam observations of very low-mass stars in GCs.

NIRSpec Multi-Object Spectroscopy of Brown Dwarfs in the Westerlund 2 Star-Forming Region

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As the lowest-mass objects created by star formation processes, brown dwarfs are essential to a complete understanding of star formation in our galaxy. Leading models of the Initial Mass Function (IMF) differ most dramatically at the extreme low-mass tail, making brown dwarfs and free-floating planets the most sensitive test population for identifying the IMF's shape and possible variations. However, the low-mass IMF remains poorly constrained due to meager samples of these faint objects in the Solar neighborhood and nearby, relatively small star-forming regions. We present JWST/NIRSpec multi-object spectroscopy of dozens of low-mass stars and brown dwarfs in the star-forming nebula surrounding the massive young Westerlund 2 cluster, the most distant brown dwarfs observed spectroscopically to date. We discuss initial estimates of the brown dwarf occurrence rate and mass distribution in this massive star-forming region.

Massive Young Star Clusters and New Insights from JWST Observations of NGC 1365

Bradley Whitmore and PHANGS

A primary new capability of JWST is the ability to penetrate the dust in star-forming galaxies to identify young star clusters that remain embedded in dust and gas. In this talk I will report on new JWST observations that have been taken of the barred spiral galaxy NGC 1365, as part of the Physics at High Angular resolution in Nearby GalaxieS, or PHANGS survey. This is one of the 19 galaxies that will be observed with JWST as part of the PHANGS-JWST portion of the project, which includes MUSE H_alpha as well as ALMA CO(2-1) observations. By combining new infrared images taken with JWST with our previously observed optical HST images we have compiled a sample of 35 massive (> 10**6 Msolar), young (< 10 My) star clusters. This is the richest population of massive young clusters of any known galaxy within 20 Mpc. Nine of these clusters are newly discovered from our JWST observations. An examination of the optical images reveals that 5 of 35 (14%) are so deeply embedded that they cannot be seen in the I band with Hubble (Av > 6 mag). This suggest that massive clusters in NGC 1365 remain obscured in the visible for ~ 1.4 ± 0.6 My. We also use the JWST observations to gain a number of new insights. These include: 1) the triggering of star cluster formation by the collision of streamers of gas and dust in the inner-arm region with gas and dust in the bar itself, 2) the presence of previously unknown structures such as bridges and overshoot regions, and 3) the existence of large numbers of candidate Single Star PAH (SS-PAH) regions in NGC 1365.

Unveiling the emergence phases of star formation: the key timescales for galaxy evolution

Angela Adamo and FEAST team

Understanding how star formation and feedback, originating at ~parsec scales, regulate the star-formation cycle at the scales of galaxies remains one of the greatest challenges in astrophysics. The advent of JWST has given us access to the emerging phases of star formation allowing us to bridge bridging the gap between the dense gas phases (with ALMA) and their resulting stellar populations (with HST). I will present initial results from the FEAST (Feedback in Emerging extrAgalactic Star clusTers) survey, a JWST cycle 1 program aimed to study embedded star formation in 6 Local Volume galaxies (<11 Mpc), representative of a broad diversity of environments (nuclear starburst vs. molecular ring, diverse arm morphologies, interacting systems, low pressure dwarf environments). Our JWST NIRCam and MIRI observations from 1--to--8 μm of NGC628 reveal a huge complexity in the temporal and spatial evolution of the star formation process taking place in giant star-forming regions. Different stages of emerging star clusters co-exist in the same region, moving away from the general simplified picture that open HII regions have ceased to form stars. Using star cluster physical properties I will outline how the temporal evolution of the nesting HII regions changes as a function of position within the galaxy. These initial results highlight the necessity to revisit the generally accepted picture of a rapid dissolution of giant molecular clouds.

JOYS: JWST Observations of Young protoStars: first results

Henrik Beuther, JOYS Team

The JOYS program is a European MIRI guaranteed time project investigating the physical and chemical properties of protostars and their immediate environment over a broad mass range from low- to high-mass regions. JOYS studies the physical characteristics of embedded disks, accretion signatures, feedback from the young protostars on their environment, primordial jets and outflows as well as the chemical gas and ice constituents of the protostellar envelopes. These goals are achieved with MIRI IFU imaging between 5 and 28mu. We will outline the scope and goals of the project and present early results towards the high-mass region IRAS23385. To mention a few preliminary results: IRAS23385 exhibits several continuum sources as well as extended gas emission. Initial results show molecular emission (CO_2, C_2H_2, CH_4) towards the central sources, potentially associated with the young disk around the protostar. The extended H_2 and [FeII] emission reveals multiple active outflows, and the ice spectra dissect several ice components. Potential accretion signatures are discussed.