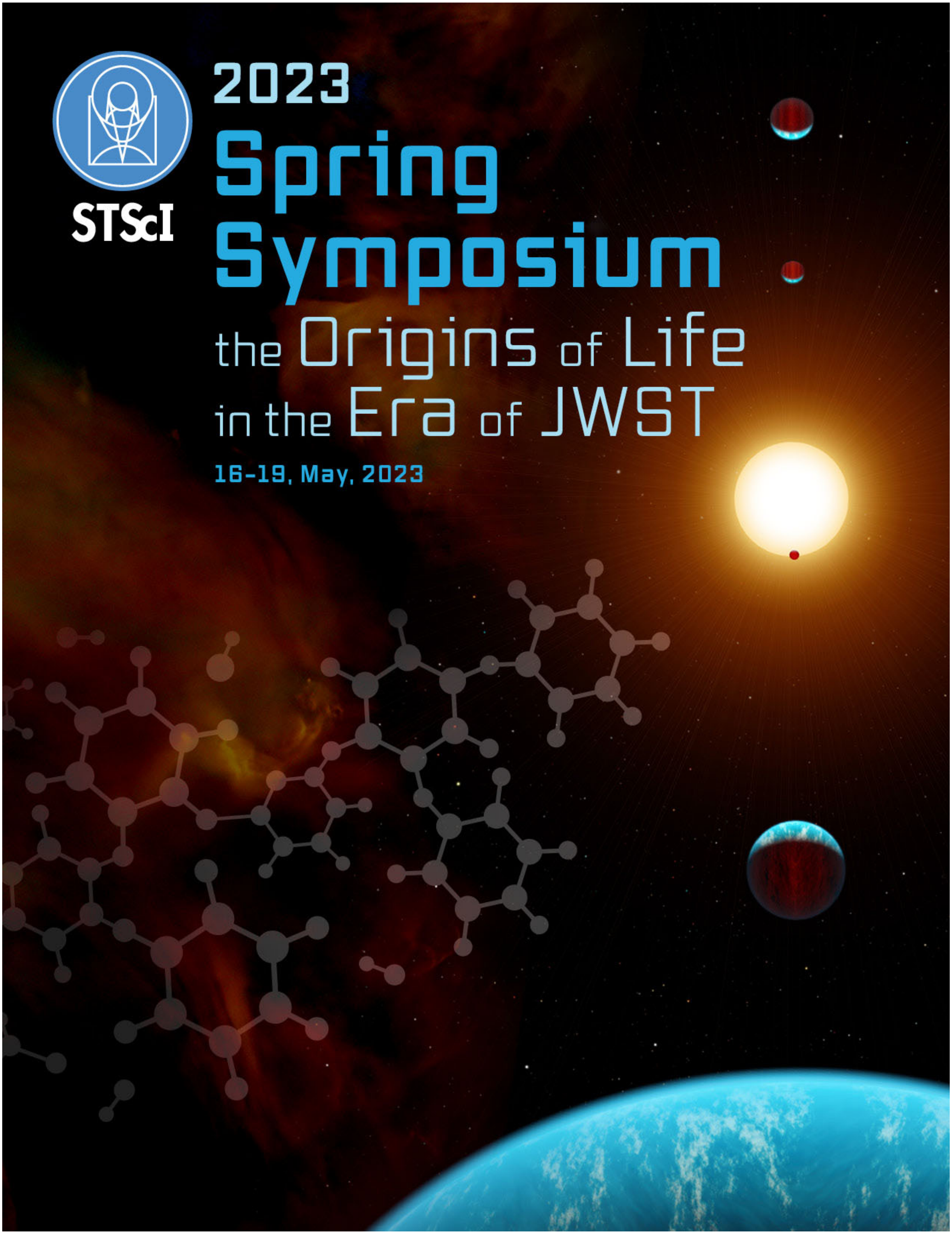
STScI
2023
Spring
Symposium
the Origins of Life
in the Era of JWST
16-19, May, 2023


Building on the foundational work enabled by HST and Spitzer, one of JWST's main scientific drivers is the study of the origins of life, from planetary formation and exoplanetary systems to investigations of our own solar system. The data to be collected through ERS, GTO, and Cycle 1 GO programs over the coming months will revolutionize our current understanding of chemical compositions within the atmospheres of exoplanets, brown dwarfs, and the planets, moons, and minor bodies of the solar system. Studies of protoplanetary and debris disks will establish fundamental initial conditions and endpoints for forming these planetary systems. The power of JWST will expand through development of multi-wavelength synergies with other missions, particularly HST, enabling astrobiologists to develop more accurate simulations of biosignatures on other worlds.

Given these exciting prospects, the 2023 STScI Spring Symposium will be on "Planetary Systems and the Origins of Life in the Era of JWST", named intentionally after one of the mission's four main science themes. The symposium will bring together researchers working on planetary systems and their precursors, the solar system, and astrobiology, stimulating discussions and exchange of ideas for future JWST cycles.

We will also hold a pre-symposium workshop for early career researchers, where local experts will provide guidance and mentorship for the upcoming generation of scientists who will use JWST on Monday, May 15, 2023. The in-person Spring Symposium will begin on Tuesday, May 16, 2023 through and including Friday, May 19, 2023.

# Agenda

Schedule - Spring Symposium 2023

# Planetary Systems and the Origins of Life in the Era of JWST

| | Tuesday (May 16th) | Wednesday (May 17th) | Thursday (May 18th) | Friday (May 19th) |
|---|---|---|---|---|
| **9:00 - 9:30** | **Introduction** | Free | | |
| **9:30 - 9:45**<br>**9:45 - 10:00** | The Chemistry of Planet Formation in the Joint JWST-ALMA Era<br>**Karin Öberg** | Webb explores the icy Solar System: Every Ice, Everywhere and all at once<br>**Noemi Pinilla Alonso** | A 1 to 20 µm Spectrum of the Planetary-mass Companion VHS 1256–1257 b<br>**Brittany Miles** | How Methane Biogeochemistry and Geomicrobiology Can Inform Astrobiology in the JWST Era<br>**Jennifer Glass** |
| **10:00 - 10:15** | A JWST-ALMA Synergy: Modeling Pebble Drift, Water Transport and the Assembly of Rocky Planets<br>**Anusha Kalyaan** | The complex compositional landscape of the outer protoplanetary disk revealed through JWST GTO observations of large Kuiper belt objects<br>**Ian Wong** | Moderate-resolution Spectroscopy of Directly Imaged Exoplanets<br>**Kielan K. W. Hoch** | Evidence for amino acids in the gas of the star-forming region IC 348<br>**Susana Iglesias-Groth** |
| **10:15 - 10:30** | JWST Reveals the Hot Water Reservoir of the AS 209 Disk<br>**Carlos Muñoz-Romero** | Discovery of 4 Spectral Classes among Trans-Neptunian Objects<br>**John Stansberry** | Direct characterization of exoplanetary systems with JWST: lessons learnt from one year of operations<br>**Jens Kammerer** | Differentiating Terrestrial Exoplanet Archetypes with Polarized Reflected Light<br>**Kenneth Gordon** |
| **10:30 - 10:40** | Flash talks #1 | Flash talks #4 | Flash talks #7 | Flash talks #10 |
| **10:40 - 11:10** | **Coffee Break** | | | |
| **11:10 - 11:40** | JWST views of the HD 141569 system: Feedback from the ERS Debris disk imaging program<br>**Elodie Choquet** | Deciphering Callisto's surface chemistry using JWST/NIRSpec<br>**Richard Cartwright (Presented by Bryan Holler)** | A deep dive into timeseries observations from the Transiting Exoplanet Community ERS Program<br>**Hannah Wakeford** | The M-dwarf Opportunity for Understanding Life as a Planetary Phenomenon<br>**Sukrit Ranjan** |
| **11:40 - 11:55** | Composition of the Terrestrial Planet-Forming Disk Regions<br>**Thomas Henning** | Widespread CO2 Among the Trans-Neptunian Population<br>**Mario Nascimento de Pra** | An Exoplanet Atmosphere in Extraordinary Detail: The Unified Near-Infrared Spectrum of WASP-39b<br>**Aarynn Carter** | Can Carbon Fractionation Provide Evidence for Aerial Biospheres in the Atmospheres of Temperate Sub-Neptunes?<br>**Ana Glidden** |

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|---|---|---|---|---|
| **11:55 - 12:10** | What debris-planet interactions can teach us about planetary systems in the JWST era<br>**Tim Pearce** | The detection of crystalline water ice on trans-Neptunian objects in JWST era<br>**Ana Carolina de Souza Feliciano** | Discovery of Thermal Emission from the Earth-sized Exoplanet TRAPPIST-1 b using JWST<br>**Taylor James Bell** | Only a Matter of Time: Ages of M Dwarf Stars and their Planets for Better Astrobiology<br><br>**Eric Gaidos** |
| **12:10 - 12:20** | Flash talks #2 | Flash talks #5 | Flash talks #8 | Flash talks #11 |
| **12:20 - 13:20** | **Lunch Break** | | | |
| **13:20 - 13:35** | Spatially resolved imaging of the Fomalhaut Asteroid Belt with JWST/MIRI<br><br>**Andras Gaspar** | Measuring the Polycyclic Aromatic Hydrocarbon Content of Comets with JWST<br>**Nathan Roth** | Characterizing the atmospheric composition and climate of potentially habitable exoplanets in the era of JWST<br><br>**Thaddeus Komacek** | Two Possible Interpretations of the JWST Transmission Spectrum of the Warm Super-Earth GJ486b<br><br>**Katherine Bennett** |
| **13:35 - 13:50** | High contrast imaging of the debris disk around Beta Pictoris<br><br>**Isabel Rebollido** | Astrobiology with JWST: Searching for life and habitability in our Solar System<br><br>**Geronimo Villanueva** | The Unexpected Detection of HR8799e with NIRCam Coronagraphy and Implications for Cycle 3<br><br>**William Balmer** | Modeling the Evolution of TRAPPIST-1c's Atmosphere Through Outgassing and Escape<br><br>**Katie Teixeira** |
| **13:50 - 14:05** | Investigating ancient reservoirs of our Solar System's earliest solid materials<br><br>**Katherine de Kleer** | | Constraining Directly Imaged Planet Formation using High Resolution Spectroscopy of Host Stars<br><br>**Aneesh Baburaj** | **Discussion** |
| **14:05 - 14:20** | | Mapping Enceladus' immense water plume with NIRSpec/JWST<br><br>**Sara Faggi** | Thermal-IR spectroscopic probes of extincted giant protoplanets<br><br>**Jordan Stone** | |
| **14:20 - 14:30** | Flash talks #3 | Flash talks #6 | Flash talks #9 | |
| **14:30 - 14:45** | **Coffee Break** | | | **Mark Clampin** |
| **14:45 - 15:00** | | | | |
| **15:00 - 15:15** | Disentangling the Origins of Planetary System | The infrared spectra of Saturn's rings from JWST | Constraints on the Atmosphere of the Super- | **Closing remarks** |

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|---|---|---|---|---|
| | Volatiles: JWST Studies of Comets<br><br>**Stefanie Milam** | **Matt Hedman** | Earth GJ 1132b from JWST NIRSpec Observations<br><br>**Erin May** | |
| **15:15 - 15:30** | Jupiter's three-dimensional atmosphere through NIRCAM observations<br><br>**Ricardo Hueso** | Giant Planet Ring-Moon Systems in JWST<br><br>**Mark Showalter** | *A JWST MIRI Dayside Emission Spectrum of the Benchmark Hot Jupiter HD 189733 b*<br>**Julie Inglis** | |
| **15:30 - 15:45** | Charon's surface composition: new insights from JWST<br><br>**Silvia Protopapa** | Revealing the rings of the centaur (10199) Chariklo from JWST through a stellar occultation<br><br>**Pablo Santos-Sanz (presenting author: Bryan Holler)** | The Importance of High-precision Stellar Fundamental Parameter and Elemental Abundance Inferences for JWST Studies of Exoplanet Atmospheres<br><br>**Kevin Schlaufman** | |
| **15:45 - 16:00** | **Discussion** | | | |
| **16:00 - 16:15** | | | | |
| **16:15 - 16:30** | | | | |
| **16:30 - 16:45** | **Social** | | | |
| **16:45 - 17:00** | | | | |
| **17:00 - 17:30** | Free | | | |
| **18:00 - 20:00** | | **Dinner** | | |

| | Tuesday, May 16th | Wednesday, May 17th | Thursday, May 18th | Friday, May 19th |
|---|---|---|---|---|
| **10:30-10:40 am** | Nick Bellering, Kate Follette, Gary Melnick, Hyerin Jang, Prasanta Kumar Nayak | Aarynn Carter, Joshua Lothringer, Yinuo Han | Carlos Ortiz Quintana, Natalie Allen, Nicolas Godoy, Marie Ygouf | Daniel Thorngren, Jordan Ealy, Jacob Haqq-Misra |
| | **Morning Coffee Break** | | | |
| **12:10-12:20 pm** | John Debes, Alycia Weinberger, Schuyler Wolff | Sagnick Mukherjee, Matthew Nixon, Polychronis Patapis, Nicole Wallack | Samuel Grunblatt, James Kirk, Romain Mayer, William Misener | Guangwei Fu, Ana Glidden, Jingcheng Huang, Laurence Denneulin |
| | **Lunch Break** | | | |
| **2:20-2:30 pm** | Steven Young, Brandon Park Coy, Bryan Holler, Michael Kelley | Kadin Worthen, Sarah Betti, Catriona Murray, Bryce Bolin | Kimberly Paragas, Anitha Raj Rajkumar, Lakeisha Ramos-Rosado, Emily Rickman | - |
| | **Afternoon Coffee Break** | | | - |

# Talks/Abstracts

**Richard J. Cartwright et al.**

**Title: Deciphering Callisto's surface chemistry using JWST/NIRSpec**

Abstract: The icy Galilean moon Callisto has an ancient surface covered by craters with bright, often disaggregated rims surrounded by a large volume of dark material of unknown origin. Callisto's apparent geologic quiescence belies its vibrant surface chemistry, sustained by CO2 and other carbon-bearing species. Observations made by the Near Infrared Mapping Spectrometer (NIMS) on the Galileo spacecraft identified a 4.25-micron band attributed to 'complexed' CO2 (i.e., molecularly bound to more refractory components) across Callisto's surface. NIMS also detected a broad absorption band near 4.57 microns that was attributed to organic residues, possibly formed via irradiation of short-chain hydrocarbons mixed with other components. However, the low resolving power of NIMS (R ~200), numerous filter junctions between 3 and 5 microns, and typically low signal-to-noise ratios (S/N) at wavelengths >4 microns limited prior analyses of these features and other, more subtle bands. Although ground-based observations have since confirmed the presence of the 4.57-micron band, Earth's atmosphere is opaque between ~4.2 to 4.5 microns, preventing analysis of CO2. Furthermore, telluric contributions between ~3.0 to 3.5 microns have hampered confirmation and assessment of possible organic features.

High quality observations of Callisto's leading and trailing hemispheres made by JWST/NIRSpec (G395H) in late 2022 have revealed this moon's spectral properties in stunning detail. We have identified CO2 absorption features across Callisto's surface. These results show that CO2 is stronger on Callisto's trailing hemisphere than its leading hemisphere, consistent with measurements made by NIMS. The hemispherical asymmetry in the distribution of CO2 might result from radiolytic production of CO2 from C-rich material on Callisto's surface, preferentially operating on its trailing side. We identify several subtle features between 3.2 and 3.8 microns that might arise from organics, as well as a broad 4.57-micron band, confirming prior identification of these spectral features. The origin of these features is unknown, and they could result from components native to Callisto's crust and/or species delivered in dust grains, which likely contribute to the ubiquitous dark material. Thus, JWST has confirmed that the surface of Callisto is rich in CO2 and refractory material that could be organic in nature, likely produced by charged particle radiolysis of native or delivered C-bearing material.

## Elodie Choquet

### Title: JWST views of the HD 141569 system: Feedback from the ERS Debris disk imaging program

Abstract: With two conoragraphic modes in the NIRCam and MIRI instruments, JWST now offers unprecedented views of young exoplanetary systems in near- and mid-infrared bands that are either completely inaccessible or have a poor sensitivity from other high-contrast imaging facilities. In the specific case of circumstellar disks, these new capabilities are valuable tools to study their dust properties and thus provide key contextual elements to understand planet formation: the NIRCam instrument gives access to the critical water ice feature at 3µm, allowing for testing the cometary nature of the dust as well for constraining the grain size distribution with wavelengths sensitive to grains larger than shorter-wavelength HST or ground-based images. The MIRI instrument probes a key transition between the scattered-light regime and the thermal emission regime, providing a better overall understanding of dust properties. The resolved mid-IR images allows us to measure the radial profile of the dust thermal emission, and disentangle the thermal properties of complex multi-ring systems. The MIRI filters also give access to silicate and PAH emission features allowing to constrain the dust composition.

The JWST ERS program for Direct Observations of Exoplanetary Systems includes such NIRCam and MIRI observations of an archetypical transition disk, the 5Myr old HD 141569 system. This system, previously imaged with all main high-contrast imaging instruments, has 3 dust belts at about 45au (~0.4”), 200au (~1.8”), and 400au (~3.6”), which test the instruments capability to image and disentangle the scattered light and thermal emission of the three rings, and to constrain their dust properties. In this talk I will present the first results of the Disk ERS team and the lessons learned from these observations.

## Eric Gaidos

### Title: Only a Matter of Time: Ages of M Dwarf Stars and their Planets for Better Astrobiology

Abstract: Earth's atmosphere has evolved over billions of years, driven by changes in solar luminosity, rates of mantle convection and crust formation, exchange of light elements between the atmosphere and interior, escape of hydrogen to space, and life. Rocky planets in the habitable zones around other stars presumably experience analogous evolution, but with varying tempo and pattern depending on the host star's properties, planet's orbital semi-major axis, mass and composition, and presence or absence of a biosphere. Correct temporal ordering of planets observed by JWST and proposed future observatories would allow such evolution and its pace to be investigated. The ages of planets are estimated by age-dating their parent stars, and the great majority of known temperate rocky exoplanets, and the most observationally accessible, orbit M-type dwarf stars. I describe recent work to more rigorously estimate the ages of late K and early M dwarf stars using stellar rotation (gyrochronology). That calibration has recently been extended to 4 Gyr, almost to the mid-point of the history of the Galactic disk. The time-rotation period relation at late times is consistent with the simple power-law relation originally predicted by Skumanich, suggesting that it can be extended to yet older stars. I describe how this gyrochronology will be improved in the future and how age assignments can be used to investigate evolution of atmospheres and, possibly, the appearance of biospheres, among samples of planets.

## Jennifer Glass

### Title: How Methane Biogeochemistry and Geomicrobiology Can Inform Astrobiology in the JWST Era

Abstract: Microbes are the dominant source of methane on Earth, and likely have been throughout Earth's history. Therefore, the detection of methane on a rocky exoplanet by JWST would be a momentous discovery, potentially indicating the presence of life. In this talk I will highlight the biological, abiotic, and coupled pathways that create methane, and will review current theories on methane as a biosignature gas. I will then discuss my group's recent work on microbial adaptations to deep subsurface methane-rich ecosystems, including gas hydrates as a habitable environment on Earth and potentially other planetary bodies inside and outside of our solar system.

## Katherine de Kleer

### Title: Investigating ancient reservoirs of our Solar System's earliest solid materials

Abstract: Remnants of our Solar System's rocky planetesimals remain today in the asteroid populations. The composition and distribution of these objects tells us about early processes in the formation and dynamical evolution of the Solar System. Within the main asteroid belt, a subset of the objects known as the L-Type asteroids are purported to contain a higher abundance of Calcium Aluminum Inclusions (CAI's) than any known meteorite by a factor of >5. CAI's are the first solids to condense out of the protoplanetary disk, and these asteroids are thus potentially the largest reservoirs of the most ancient solid material. We are in the process of collecting JWST spectra at 2.5-28 microns on these objects in order to determine their mineralogical make-up, and to constrain their disk formation region and thermal/aqueous alteration histories. In addition, we have been building a spectral library of different classes of CAIs in the laboratory for comparison with JWST spectra. We will present results on the laboratory and JWST data obtained to date, which includes full spectral coverage of two of our asteroid targets. A confirmation of the high CAI content of these objects would have important implications for the timing of events in the Solar System's early history and the origins of the Solar System's raw materials.

## Brittany Miles

### Title: A 1 to 20 µm Spectrum of the Planetary-mass Companion VHS 1256–1257 b

Abstract: I will present the highest fidelity spectrum to date of the planetary-mass object, VHS 1256 b which shares similar colors with the directly imaged exoplanets HR 8799c, d, and e. The Early-release Science Program for Direct Observations of Exoplanetary Systems spectrum covered1- 20 microns by using the NIRSpec and MIRI IFU modes of JWST. At medium resolution we have detected Water, methane, carbon monoxide, carbon dioxide, sodium, potassium, along with evidence of carbon dioxide. Comparisons between atmospheric models and previously published brown dwarf spectra reveals an atmosphere influenced by atmospheric mixing and cloudiness. I will discuss the implication of these results and their impact on future brown dwarf science with JWST.

## Karin I. Öberg

### Title: The Chemistry of Planet Formation in the Joint JWST-ALMA Era

Abstract: Planet formation is intimately linked to the chemical compositions of the disks within which planets assemble. Disk chemical structures affect planet formation efficiencies, bulk elemental compositions of planets and planetesimals, as well as access to water and prebiotic organics for potentially habitable planets. Obtaining complete disk chemical radial profiles is then key to develop a predictive theory of planet formation, and a comprehensive interpretative chemical framework for (exo-)planetary abundances. In the past year we have entered a privileged time where we have detailed access to outer disk gas with ALMA, and icy grain compositions and the inner disk gas with JWST. By combining molecular observations from JWST and ALMA we can then constrain the disk chemistry across all disk radii and volatile phases relevant to planet formation, as well as begin to identify and characterize dynamical and chemical links between different disk regions. In this talk I will present the first results from our JWST program, which leverages existing, high-spatial resolution ALMA chemistry data from MAPS to enable a joint JWST-ALMA disk chemistry approach. I will also discuss the theoretical and laboratory developments that are needed to fully exploit these kinds of data sets, and possible future expansions.

## Noemi Pinilla Alonso

### Title: Webb explores the icy Solar System: Every Ice, Everywhere and all at once

Abstract: Over the past five years, the James Webb Space Telescope (JWST or the Webb) has captured the attention of the planetary community, as evidenced by the extensive list of programs awarded time through GTO, GO-1, and presumably GO-2. Of the four science instruments on board, two spectrographs, NIRSpec and MIRI, have generated the most interest among planetary scientists. With spectroscopic capabilities ranging from 0.6 to 28 microns and a resolving power of 100 to 3,250, the Webb's observing modes provide a unique opportunity to obtain data of unparalleled quality, especially when studying icy small bodies in the outer reaches of our solar system, from small centaurs to large dwarf planets. Now, approximately one year after scientific operations began, the James Webb Space Telescope and its four science instruments are already producing significant new insights in many areas of solar system astronomy. Spectroscopy beyond 2 microns is crucial for assessing the relative ratios of water ice, complex organics, silicates, and volatiles on the surface of a large sample of Trans-Neptunian Objects (TNOs). This information is vital to tell the story of the formation of our solar system and other planetary systems, and is relevant to disciplines such as astrochemistry, cosmochemistry, and astrobiology. It also has implications for our understanding of the origin of water and life on Earth, and potentially elsewhere. In this talk, we will present some highlights of the first 10 months of operations of JWST, in particular, the study of icy small bodies including the large program DiSCo: Discovering the Surface Composition of TNOs, as well as several projects awarded Guaranteed Telescope Time. Many of the results we highlight will be presented in greater detail in subsequent talks during the conference.

## Sukrit Ranjan

### Title: The M-dwarf Opportunity for Understanding Life as a Planetary Phenomenon

Abstract: Advances in origins-of-life chemistry are transforming our understanding of how life emerged on Earth, while current and upcoming facilities offer the prospect of detecting life on other worlds. Fundamental to both quests is interaction of UV radiation with molecular systems (photochemistry). Photochemistry controls the chemical context in which life originates and influences the molecular signposts with which we hope to detect life elsewhere. Planets orbiting low-mass M-dwarf stars are uniquely accessible to observational characterization but experience a very different photochemical environment than planets orbiting Sunlike stars. In this talk, I will discuss the UV emission of M-dwarf stars and the implications for the habitability of their planets. I will discuss efforts to elucidate potential atmospheric biosignatures of life on M-dwarf planets and show how the search for life on such worlds may enable tests of theories of abiogenesis.

## Geronimo Villanueva

### Title: Astrobiology with JWST: Searching for life and habitability in our Solar System

Abstract: JWST is opening a new era in the astrobiological exploration of our Solar System. Recently and using orbiters and ground-based observatories we established that Mars lost an ocean's worth of water, while the Curiosity rover has recently detected organics on the Martian surface and in the atmosphere. Organic rich oceans have been suggested to exist under the surface of Europa, Enceladus. If these planets/moons had a rich chemical and diverse past, how much of these volatiles were lost to space, and how much are currently available for life? Are there sub-surface habitable niches connecting now with the atmosphere?

Sensitive infrared spectroscopy is one of the most powerful methods to address fundamental questions of planetary evolution and habitability, by permitting to probe water, other key volatile species and also importantly organic compounds. Telluric extinction and background-noise limit our sensitivity to measure these species from ground, while orbiters and previous observatories generally do not have the wavelength range, coverage or sensitivity to deeply probe these species. With the recent arrival of the James Webb Space Telescope (JWST) to the L2 point, a new window now opens for the exploration of the solar system and beyond at infrared wavelengths.

In this presentation, I will present our JWST latest results as obtained with the Mars GTO and Ocean Worlds (Europa / Enceladus) GTO programs. These observations demonstrate the unique capabilities of this new observatory for fundamental Solar System research, and set the foundation for future dedicated measurements of astrobiologically relevant species and processes.

## Hannah R Wakeford

### Title: A deep dive into timeseries observations from the Transiting Exoplanet Community ERS Program

Abstract: The Transiting Exoplanet Community Early Release Science Program is providing a first deep dive into JWST spectroscopic time-series data across all four instruments and in five different observing modes. In this talk I will introduce the JTEC ERS program and showcase the work done across three work packages and a multitude of ancillary work spawned by the exquisite data. I will end with lessons learned and exciting new avenues in exoplanet science to explore through the program and place the work in the context of the wider set of exoplanet studies on JWST.

## Contributed talks

## Protoplanetary/Debris Disks:

### Andras Gaspar

#### Title: Spatially resolved imaging of the Fomalhaut Asteroid Belt with JWST/MIRI

The A4V spectral-type star Fomalhaut hosts one of the most prominent and spatially well resolved debris disk systems, with a well defined outer Kuiper-belt analog narrow ring. The inclined viewing angle and close proximity of the system enables detailed studies of its structure as well as the chemical composition of its dust content. Observations with the Spitzer Space Telescope revealed the system to host an inner disk component located at a distance thermally equivalent to that of the asteroid-belt around the Sun, establishing Fomalhaut as an archetypal disk system. In this talk, we report on imaging of this exo-asteroid-belt at mid-infrared wavelengths using JWST/MIRI, the first time such a disk component has been spatially resolved. We also announce the discovery of an intermediate belt/arc in the Fomalhaut system, located in between the newly imaged asteroid-belt analog disk and its well known outer Kuiper-belt analog (KBA) ring. The intermediate belt/arc is demarcated by a secondary inner gap, located at ~ 78 au from Fomalhaut, equivalent to a thermal location of approximately 58 K. The extrasolar object Fomalhaut b could have originated from the intermediate-belt, where we anticipate higher planetestimal number densities and increased dynamical stirring. We also report the discovery of new features, such as a large spherical dust cloud within the KBA ring and a misalignment between the ring systems.

### Thomas Henning

#### Title: Composition of the Terrestrial Planet-Forming Disk Regions

The chemical composition and physical state of the inner regions of planet-forming disks determine the pathway towards terrestrial planets and their content in water and organics. Sensitive infrared spectroscopy is the best strategy to characterize the molecular composition of the inner planet-forming zones. The JWST MIRI mid-INfrared Disk Survey (MINDS) is providing data for more than 30 disks around T Tauri stars and 10 low-mass disks around brown dwarfs. This contribution will present and discuss the first MINDS results. We discovered a completely unexpected rich hydrocarbon chemistry, including $C_2H_2$, $C_4H_2$, and the ring-molecule benzene, in the inner disk (0.035 au) around a very low-mass star. This observation indicates the presence of a dust trap for water-rich pebbles. Another amazing detection is the observation of water in the very inner disk of the PDS 70 planet-hosting system. The study of the GW Lupi disk shows an unusually high $CO_2/H_2O$ ratio, probably caused by an ice trap between the snowlines of $CO_2$ and $H_2O$. These results highlight the power of JWST spectroscopy for our understanding of the inner regions of planet-forming disks.

## Anusha Kalyaan

### Title: A JWST-ALMA Synergy: Modeling Pebble Drift, Water Transport and the Assembly of Rocky Planets

Mm-interferometry is sensitive to the presence of structure (such as gaps, rings) in the outer disk, while IR spectra provide access to gaseous molecules (such as H2O) residing in the warm inner regions. When combined, these observations can provide insight into the complete picture of the radial transport of water in icy pebbles which drift inwards from the outer disk and sublimate into vapor within the water snow line. Moreover, they also provide unique constraints into the pebble-mass flux entering the inner disk, crucial for rocky planet formation. Previous observations suggest an anti-correlation between water luminosity and outer dust disk radius, implying a link between disk structure and inner disk vapor enrichment (Banzatti et al. 2020) and is verified by numerical simulations with a snowline-disk evolution model (Kalyaan et al. 2021). We now improve upon the previous modeling to include a full dust population and planetesimal formation, and explore various parameters (such as fragmentation velocity of dust grains, disk turbulence, and location and filtering efficiency of gaps) that impact the evolving inner disk vapor abundance. With Cycle-1 JWST MIRI Spectra (GO 1640) being obtained in February-March 2023, we will measure inner disk water column densities in a sample of disks with different sizes and gap structures and predict the architecture of their planetary systems.

## Carlos Muñoz-Romero

### Title: JWST Reveals the Hot Water Reservoir of the AS 209 Disk

The presence of water plays a fundamental role in planet formation. Water is expected to be the main oxygen carrier in disks, a cornerstone for the formation of complex organics and prebiotic molecules, and an essential ingredient for habitability. Similarly, water ice assists the growth of pebbles and planetesimals, and its distribution regulates disk dynamics. Our limited understanding of water in the terrestrial planet-forming region of disks comes from Spitzer, which revealed that warm water is ubiquitous in the inner disk regions of low-mass T Tauri stars. Now, the unique sensitivity, resolution, and wavelength coverage of JWST offers the opportunity to characterize the properties of water vapor in disks with unprecedented detail. We report the detection with MIRI MRS of hundreds of ro-vibrational and rotational water lines towards the inner disk of AS 209, a low-mass T Tauri star with a rich outer disk chemical reservoir. To model the spectra, we developed a Gaussian Processes pipeline that simultaneously accounts for water lines, continuum emission, residual instrumental fringes, and unknown molecular lines. The column density, distribution, and excitation conditions of water in the disk were then retrieved within a Bayesian framework, revealing multiple water reservoirs in the disk. I will discuss the implications of these results in the context of planet formation, disk dynamics, and the connection between inner and outer disk chemistry.

## Tim Pearce

### Title: What debris-planet interactions can teach us about planetary systems in the JWST era

Debris discs have long been used to probe the outer regions of planetary systems, allowing otherwise-undetectable planets to be inferred from their influence on observed debris. Now, for the first time, JWST gives us the opportunity to directly detect these outer planets. Combining such planet detections with debris-disc morphologies and dynamical-interaction theory would open up a wealth of powerful new insights into planetary systems. In this talk I review the deep and wide-ranging insights possible now that JWST can detect the planets long-predicted to be interacting with debris discs. These include the first-ever means to measure debris-disc masses (throwing light on the enigmatic 'debris-disc mass problem'), determining the historical orbital evolution of imaged exoplanets (not possible with other techniques), constraining sub-detection-limit system architectures, and even measuring the size of primordial planetesimals (providing direct tests for planetesimal-formation theories). I will demonstrate how exploiting the planet-detection capability of JWST in debris-disc systems would throw open a new window into planetary system formation, architecture and evolution, and ultimately help put our own Solar System into context. The talk should be accessible to those without detailed knowledge of debris discs or planetary system dynamics, and will directly reference my upcoming Cycle 1 programmes and Cycle 2 proposals to demonstrate some of the insights that JWST should provide.

## Isabel Rebollido

### Title: High contrast imaging of the debris disk around Beta Pictoris

The prominent disk around the star Beta Pictoris is one of the best studied due to its proximity (19 pc), extended size (up to 1800 au) and large surface brightness. It was in fact the first debris disk to be ever imaged in 1984 by Smith & Terrile. Since then, the astronomical community has thoroughly investigated this system, finding large amounts of dust and gas, exocomets, and two planets. All of this makes it the perfect laboratory to investigate the dynamics and chemistry of the late stages of planet formation. The JWST GTO 1411 program was designed to investigate the dust component at near- and mid-infrared wavelengths, providing new insights on the dust morphology, composition, and distribution. The combination of the high sensitivity of the on board instruments with the 4QPM and Lyot coronagraphs allows for the most detailed images of the Beta Pictoris disk so far at this wavelength range, revealing new features and details in the dust distribution. In this talk, I will present for the first time the new JWST/MIRI coronagraphic images at 15.5 and 23 microns. I will also summarize the analysis of the new observed disk features, and compare it to previous ground and space based observations at multiple wavelengths.

## Solar System/Extrasolar Minor Bodies:

### Stefanie Milam

#### Title: Disentangling the Origins of Planetary System Volatiles: JWST Studies of Comets

Comets provide important constraints to the processes that occurred during the formation and early evolution of the Solar System. The composition of nuclei is determined primarily from the remote detection of material found in their atmospheres, with extremely few dedicated missions to flyby, orbit, land on, or collect samples from the coma and the nucleus. Previous ground- and space- based observations, including recent Rosetta results, as well as laboratory measurements of cometary material obtained from Stardust, suggest that comets contain a mixture of the products from both interstellar and nebular chemistries. A major observational challenge in cometary science is to quantify the extent to which chemical compounds can be linked to either reservoir. By understanding the native volatile composition, understanding the physiochemical conditions of the comet upon sublimation, as well as the dust and bulk solid composition, the pristine nature of these objects can be deciphered. JWST's unprecedented sensitivity, spectral coverage, imaging capability, and support for tracking non-sidereal objects makes it an ideal tool for studies of these small bodies. We will present recent results from JWST towards comets C/2022 E3 (ZTF) and C/2017 K2 (Pan-STARRS) and will discuss the volatile, organic, and dust composition as well as new discoveries enabled by this facility for cometary science with applications to planet formation in the Galaxy.

### Mario Nascimento De Pra

#### Title: Widespread CO2 Among the Trans-Neptunian Population

Carbon dioxide (CO2) is one of the most abundant ices in the Solar System. It has been detected on the giant planets and their moons, comets, and even in regions of Mercury, the Moon, and Mars. Furthermore, it was also found in Interstellar Molecular Clouds and, recently, in the exoplanet WASP-39b. Accordingly to some planetary formation models, trans-Neptunian objects (TNOs) predominantly accreted in the region beyond the CO2 snow line, and depending on their sizes, they could have retained this ice until the present era. Nonetheless, CO2 ice among TNOs has not yet been detected, mainly due to the faintness of these bodies, which makes observations at wavelength regions where the CO2 fundamental absorption feature is located (at ~4.27 micrometers), or high-resolution spectroscopy near its overtones, challenging or impossible with ground-based facilities. Webb's large program DiSCo-TNOs (PID 2418) is observing 59 TNOs with NIRSpec to identify and characterize the CO2 ice among the population. A preliminary analysis of nearly half of the DiSCo sample indicates widespread evidence of CO2 on TNOs, with most objects showing a spectral feature at 4.27 micrometers and several displaying overtone features at 2.69 and 2.78 micrometers. In this work, we investigate the characteristics of these CO2 signatures in relation to the object's sizes, dynamical classes, presence of other ices, and other physical properties. The findings of this work have significant impact on our understanding of the early Solar System and its evolution, models for volatile retention, and on the formation of other planetary systems and debris disk.

## Silvia Protopapa

### Title: Charon's surface composition: new insights from JWST

Spectral measurements of Pluto's largest satellite, Charon, obtained from ground and space (New Horizons mission), revealed a surface dominated by crystalline water ice and ammonia-bearing species, which appear enhanced in the bright ejecta blankets of geologically young craters, possibly exposing subsurface material, and darkening compounds. A suite of different mechanisms at play on the surface of Pluto's largest satellite have been identified (e.g., radiation processes, cratering histories) and established links between Charon, Kuiper Belt objects, icy satellites, asteroids and comets have provided valuable insights into possible common inventories in the regions of the solar nebula where these objects formed. However, these measurements also raised questions that could not be addressed given the limited spectral coverage of New Horizons up to 2.5 micron. These include, but are not limited to, the exact identity of the ammonia-bearing species on Charon responsible for the 2.2-µm absorption band (possibilities include $NH_3$ frozen within the $H_2O$ ice and ammoniated salts) and the lack of spectral features of other compounds (e.g., $CO_2$) present in the region of the solar nebula where the Pluto system formed and expected to be exposed on the surface together with crystalline water ice and ammonia-bearing species. The synergy of JWST NIRSpec observations of Charon covering the wavelength range 1.0-5.2 micron, laboratory measurements, and modeling techniques together shed light on these so far unanswered questions. We will present our current knowledge of Charon's surface composition in view of the recently acquired disk-averaged JWST measurements and spatially resolved New Horizons data.

## Pablo Santos-Sanz (presenting author: Bryan Holler)

### Title: Revealing the rings of the centaur (10199) Chariklo from JWST through a stellar occultation

Rings around minor bodies have recently been discovered around the centaurs Chariklo (Braga-Ribas + 2014) and Chiron (Ortiz + 2015; Sickafoose + 2019), the dwarf planet Haumea (Ortiz + 2017), and the trans-Neptunian object Quaoar (Morgado + 2023). Such rings provide important clues to the dynamical and collisional history of the outer Solar System (Araujo + 2018; Wood + 2018), as well as to the formation mechanism of satellites, which is under debate after the discovery of the ring of Quaoar outside its Roche limit (Morgado + 2023). Another important open question is to unravel how these dense rings are confined and why they appear to be closer to the 3:1 spin-orbit resonance (Sicardy + 2019, 2020). With all this in mind, we predict and observe a stellar occultation by the ringed centaur Chariklo from JWST on October 18, 2022. We will present the results of this occultation detected by NIRCam as part of Heidi Hammel's GTO program ID 1271. This is the first stellar occultation observed from JWST and is a successful proof of concept of the feasibility of JWST to characterize solar system objects using this powerful technique. The challenging tasks performed to predict the stellar occultation visible from JWST and the instrumental setup used to observe this occultation will also be discussed. Finally, we will present preliminary results from this successful stellar occultation, showing us in-depth details of Chariklo's rings and possibly other structures.

## John Stansberry

### Title: Discovery of 4 Spectral Classes among Trans-Neptunian Objects

Prior to JWST, compositions of trans-Neptunian objects (TNOs) could only be precisely measured for high-albedo objects larger than about 800 km diameter (with the Centaur Pholus and New Horizons mission targets excepted), and generally only shortward of 2.3 µm. Such objects are large and cold enough to retain volatile ices ($CH_4$, CO, $N_2$) on their surfaces, so their spectra don't reflect bulk composition. Smaller TNOs are unlikely to have differentiated, so their surface compositions are more likely to reflect the primordial composition of the outer proto-planetary disk from which they formed. Determining relationships between the compositions of these smaller TNOs and their dynamical classes has been a driving principle since soon after the discovery of TNOs. We present DiSCo-TNOs (PID 2418) and GTO (PID 1191) NIRSpec low-resolution, 1 – 5 µm spectra of 30 typical TNOs (diameters of 300 – 1000 km and low to moderate albedos). These spectra reveal detailed information about their compositions. In particular, these objects all have a signature at the 4.27 µm $CO_2$ ice fundamental. The nature of that signature varies considerably, though, and suggests highly unusual scattering behavior from some of these surfaces. Further, the nature of the 4.27 µm signature correlates with absorption bands caused by $H_2O$, CO, $^{13}CO_2$, sulfur compounds, and high-order organic compounds. The spectra fall into 4 distinct categories with overall spectral shape remarkably consistent for the objects within each category. We will discuss the implications of these spectral classes.

## Ian Wong

### Title: The complex compositional landscape of the outer protoplanetary disk revealed through JWST GTO observations of large Kuiper belt objects

Kuiper belt objects (KBOs) are remnants from the earliest epochs of planetesimal formation and hold the key to understanding the primordial environment in the farthest reaches of the protoplanetary disk. As part of Cycle 1 Guaranteed Time Observations, JWST has carried out NIRSpec IFU observations of more than a dozen KBOs. These observations have targeted some of the largest objects in this region, including the Pluto–Charon binary system, the dwarf planets Eris, Sedna, Gonggong, and 2002 MS4, and members of the Haumea collisional family. These targets span a broad range of representative surface types and dynamical classes attested throughout the Kuiper Belt, which enable us to tie their measured properties to the initial compositional architecture of the outer protoplanetary disk. Additionally, unlike their smaller, more primitive counterparts that have been observed through other programs, these large GTO targets allow us to assess the consequences of secondary evolutionary processes (e.g., internal differentiation, tenuous atmospheres, collisions) on the present-day surface properties. We have combined advanced data processing methodologies with detailed compositional modeling to study the reflectance spectra of the observed KBOs. Our analysis has uncovered a slew of previously undetected molecular absorptions, yielding unprecedented constraints on ice composition and revealing a highly complex compositional landscape that has challenged our previous understanding of Kuiper belt formation and evolution. We also compare our results with previous ground- and space-based spectra, as well as spatially resolved spectroscopy from the 2015 New Horizons flyby of the Pluto–Charon system.

## Large Scale Solar System:

## Sara Faggi

### Title: Mapping Enceladus' immense water plume with NIRSpec/JWST

By using the NIRSpec IFU instrument onboard JWST, we mapped an immense plume of water vapor (H2O) emanating from the Saturnian moon Enceladus. The observations directly sampled the fluorescence emissions of H2O well beyond the dense local plume structure near Enceladus and extend out to at least 10,000 km (40 RE, Enceladus radii), revealing an extensive plume structure embedded in a large bath of emission originating from the Enceladus torus. We performed searches for several non-water gases (CO2, CO, CH4, C2H6, CH3OH), but none were identified in the spectra. On the surface of the trailing hemisphere of Enceladus, we observe strong water ice features, including its crystalline form, yet we do not recover CO2, CO nor NH3 ice signatures from these observations. The ability to sensitively characterize the surface of Enceladus and map its plume and torus demonstrates how JWST opens a new window for the exploration ocean worlds, with unprecedented sensitivity and spatial resolution, revealing unique information regarding the processes acting beneath the moons' thick ice crusts, and the potential for habitability for the sub-surface ocean.

## Matt Hedman

### Title: The infrared spectra of Saturn's rings from JWST

As part of GTO program 1247 JWST observed different parts of Saturn's rings with both NIRSpec and MIRI. These instruments returned extremely high signal-to-noise near-infrared and mid-infrared spectra of the rings. These spectra are dominated by features due to crystalline water ice, which is consistent with previous Cassini data indicating that these rings are composed of extremely pure water ice. The high signal-to-noise of these spectra also allow us to confirm the existence of a weak band due to D-O bonds that Clark et al. (2019 Icarus) used to constrain the D/H ratio for Saturn's rings. These high-quality spectra should therefore provide extremely strong constraints on the non-water-ice components of Saturn's rings. In particular, improved constraints on the organic content of the rings could provide further information about how much meteoritic debris has contaminated the rings, a key parameter for constraining their age.

## Ricardo Hueso

### Title: Jupiter's three-dimensional atmosphere through NIRCAM observations

JWST obtained NIRCAM observations of Jupiter's atmosphere as part of a larger ERS program (1373). The Jupiter images demonstrated the capability of the telescope to obtain exquisite high-resolution images of a bright and rapidly rotating target. Observations obtained with a separation of one Jupiter rotation (10 hours) show atmospheric dynamics at altitudes that range from the upper cloud layer to the tropopause and above. NIRCAM images of Jupiter's upper hazes surpass any previous observation of these altitudes, allowing measurements of atmospheric dynamics in the transition region between the upper troposphere and the lower stratosphere. The equatorial region is a particularly interesting location covered by elevated hazes. Thermal oscillations in the equatorial stratosphere follow a quasi-periodic cycle driven by the unknown amount of energy exchange between the troposphere and the stratosphere. NIRCAM images revealed a narrow equatorial jet at the tropopause in the limit between these two regions. The jet has different intensity at different altitudes and shares many features with the equatorial dynamics of Saturn as it was observed by the Cassini mission. In both planets complex equatorial jets change in altitude from the troposphere to the stratosphere where cyclic thermal variations occur over years unrelated with seasons. We will also present results of the upper circulation in Jupiter's Great Red Spot, and in cyclonic regions with strong activity at unexpected high atmospheric levels. Our observations show atmospheric mechanisms that will drive atmospheric phenomena in the upper tropospheres of giant exoplanet atmospheres.

## Nathan Roth

### Title: Measuring the Polycyclic Aromatic Hydrocarbon Content of Comets with JWST

Comets are primitive remnants of solar system formation, cryogenically preserved in the outer solar system for the last 4.5 Gyr and retaining a record of the volatile and refractory material incorporated into their nuclei from the protosolar disk. Decoding the chemistry of the disk midplane (the comet formation region) based on present-day cometary studies requires discerning the extent to which comets incorporated interstellar vs. nebular matter. Characterizing their polycyclic aromatic hydrocarbon (PAH) content affords a window into the heritage of soluble refractory organics preserved in comets. PAHs are found in diverse environments, from evolved stars, to the interstellar medium and meteorites. The relative intensities and peak positions of their near- and mid-IR bands are diagnostic of the mixture of PAHs and complex hydrocarbons present. The unprecedented sensitivity and spectral coverage of the James Webb Space Telescope will enable characterization of these PAHs in an unheated cometary sample. These cometary spectra will be compared with those of extrasolar sources (e.g., the interstellar medium, evolved stars) to investigate the heritage of soluble cometary refractory organics, and trace cometary PAHs to their origins in the PAH evolution that occurs alongside the stellar lifecycle. We will discuss preliminary results from our JWST Cycle 1 GO program targeting cometary PAHs and the insights that could be gleaned into the PAH evolutionary process, including the heritage of refractory organics incorporated into cometary nuclei.

## Mark Showalter

### Title: Giant Planet Ring-Moon Systems in JWST

We have been examining recent NIRCam observations of the ring-moon systems of Jupiter and Neptune. These systems allow us to observe a variety of dynamical processes that are also at work in protoplanetary disks and exoplanet systems, but can be seen in vastly finer detail. The Jupiter system was imaged as a part of ERS program 1373 as well as calibration program 1022; Neptune was imaged in program 2373. These rings are optically thin and composed primarily of fine, micron-sized dust. Such tiny particles respond to a variety of non-gravitational forces, including solar radiation pressure, Poynting-Robertson drag, and magnetic perturbations. Due to their limited lifetimes (as short as decades), they must be continuously replenished from a population of larger, embedded source bodies, although these source bodies have never been detected directly. The search for the unseen source bodies within the dusty rings is a unique capability of JWST. The rings and small moons are notable for being exceedingly faint relative to their central planets, with brightness ratios ~ 10^-8 not uncommon. Studies of faint, broad features and searches for moving targets adjacent to the exceedingly bright giant planets present unique challenges for NIRCam data analysis. Nevertheless, the images reveal exquisite details of these systems, including clear detections of several features not seen previously except during reconnaissance by interplanetary spacecraft. Images through broad color filters also provide new constraints on composition and the particle size distribution. We will present the latest results from this analysis.

## Ana Carolina de Souza Feliciano

### Title: The detection of crystalline water ice on trans-Neptunian objects in JWST era

Trans-Neptunian objects (TNOs) are leftovers of planetary formation that hold clues to the chemical and physical conditions in the proto-planetary nebula. Water ice is known to be widespread in the trans-Neptunian region at temperatures compatible with its amorphous phases. Before JWST, crystalline water ice was detected on only a few TNOs, based on the 1.65-micron feature; this was surprising given that laboratory studies showed that below 105K, water ice changes to the amorphous phase. To explain the presence of crystalline water ice at such low temperatures, mechanisms such as collisions, cryo-volcanism, and impact gardening were suggested. Laboratory and theoretical studies were performed to determine whether primordial crystalline water ice could survive for the age of the solar system. In this work, we show the unprecedented contribution of Webb detecting crystalline water ice at 3.1 microns on large TNOs in the GTO-1 sample and in a diverse sub-sample of DiSCo-TNOs data, even on those with tiny amounts of water ice. The prevalence of crystalline water ice, and its mixture with the amorphous phase, provide constraints and implications on the irradiation regime in the trans-Neptunain region, on our understanding of the thermodynamics and crystalline phase predominance. Furthermore, it could provide crucial information on the formation, stability, and detectability of different chemical species in our and other planetary systems.

## Exoplanets & Brown Dwarfs:

### Aneesh Baburaj

#### Title: Constraining Directly Imaged Planet Formation using High Resolution Spectroscopy of Host Stars

Direct imaging surveys have led to recent discoveries of Jupiter-like planets that are widely separated from their host stars and cannot be easily explained by leading theories of planet formation. Elemental abundances in the atmospheres of these companions and their hosts have been postulated to reveal formation information. The comparison of these abundances (such as C/O ratios) of these gas giants to their host stars, with predictions of current theoretical models, imply different abundance ratios depending on the formation mechanism. Several active projects are involved in measuring the C/O ratios of the directly imaged planets, including ongoing JWST Cycle 1 (ID#2044) and GTO (ID# 1414) programs using the NIRSpec and MIRI instruments. However, the companion C/O ratios cannot be interpreted without the corresponding knowledge of the host stars, which have poorly constrained abundances. We have started a comprehensive survey of directly imaged planet host stars to constrain the abundances of 15 elements, specifically carbon and oxygen, and therefore the C/O ratio. We present the first results from this survey, in which we have obtained high-resolution (R~100,000) Automated Planet Finder (APF) optical spectra of 5 F/G-type host stars with well-studied companions. We are able to estimate the carbon and oxygen abundances at an accuracy of ~0.1 dex and C/O at an accuracy of ~20%. These results complement the C/O ratios of the companions obtained using spectroscopy from ground-based telescopes and JWST, which allows us to better constrain their formation pathways.

### William Balmer

#### Title: The Unexpected Detection of HR8799e with NIRCam Coronagraphy and Implications for Cycle 3

We discuss the ability of JWST coronagraphs to detect and characterize young-self luminous planets at close separations, 0.3-0.5” of their host stars. At these separations, 4 microns coronagraph imaging of young stars within 20-30 pc has the potential to directly identify giant planets within 10 AU of their host star, near the peak of the giant planet distribution recently identified by radial velocities. We start our analysis by discussing GTO NIRCam coronagraphic observations of the HR 8799 system (Program 1194) using the MASK335R, and in particular our unexpected recovery of the innermost planet “e” at 0.4”. This detection, well beneath the nominal inner working angle of the MASK335R coronagraph (0.63”), has major implications for searches for exoplanets with the observatory. We model the wavefront performances of the telescope that relates to this achieved on-sky contrast, with the planet attenuated by a factor of 10 by the coronagraph mask. Based on the wavefront stability empirically determined from these observations, we discuss NIRCam capabilities using coronagraph masks with more aggressive Inner Working Angles (MASK210R, MASKSWB). We present detection limits for a handful of emblematic targets to inform Cycle 3 proposals.

## Taylor James Bell

### Title: Discovery of Thermal Emission from the Earth-sized Exoplanet TRAPPIST-1 b using JWST

Secondary eclipses occur when exoplanets pass behind their stars, and observations of these events have been useful for characterizing the surfaces and atmospheres of numerous exoplanets with temperatures >1000 K. Of all currently-known temperate terrestrial exoplanets, the warmer planets of the seven-planet TRAPPIST-1 system are best suited for characterization via this technique. In my talk, I will present secondary eclipse observations of the Earth-sized TRAPPIST-1 b exoplanet using the F1500W filter of the JWST's MIRI instrument. We clearly detect the secondary eclipse in each of five separate observations and find that the five eclipse depths are all consistent with each other. This is the first detection of any electromagnetic radiation from an exoplanet as small as the Earth and as cool as some planets in our Solar System. I will discuss the temperature we infer for the planet and the implications that has for the possibility of an atmosphere around the planet.

## Katherine Bennett

### Title: Two Possible Interpretations of the JWST Transmission Spectrum of the Warm Super-Earth GJ486b

With the launch of JWST, the door to the characterization of rocky exoplanets and (ultimately) the search for life has opened. As the smallest and coolest stars, M-dwarfs are host to compact systems that are the most amenable to characterization. This has driven the exoplanet community to focus on the “M-dwarf opportunity”, but the question of whether exoplanet atmospheres can endure in the close-in, high-energy environment of M-dwarf stars remains almost entirely unknown. The search for the dividing line between rocky exoplanets with atmospheres and those without has been christened the “cosmic shoreline”. The JWST Cycle 1 GO program 1981 plans to shed light on this shoreline for M-dwarf systems by using transmission spectroscopy to probe five nearby rocky exoplanets. In this presentation, we report on our results for GJ 486b, a warm (703 K) 1.3 Earth-radii planet orbiting an M-dwarf in a 1.47-day orbit. We observed two transits of GJ 486b with JWST/NIRSpec’s G395H mode. We show the transmission spectrum between 2.9–5.3 µm and discuss the most plausible atmospheric composition (or lack thereof) for the planet derived from atmospheric retrievals and forward models. This is the second planet observed in our program, and we compare our results to those from the first planet observed, LHS 475b (Lustig-Yaeger & Fu et al. 2023). Using these results, we begin to place constraints on the nature of the cosmic shoreline of M-dwarf systems and the likelihood for rocky exoplanets in these systems to host compact and durable atmospheres.

## Aarynn Carter

### Title: An Exoplanet Atmosphere in Extraordinary Detail: The Unified Near-Infrared Spectrum of WASP-39b

The Panchromatic Transmission sub-program within the "JWST Transiting Exoplanet Early Release Science Program" (1366) has recently performed a range of complementary observations of the Saturn mass exoplanet WASP-39b. Spanning 0.5-5.2 microns, and using four instrumental modes across NIRCam, NIRSpec, and NIRISS, each of these datasets provide transmission spectra of unprecedented precisions at wavelengths never probed before. In this talk, I will present the first homogenous analysis of these datasets, which in totality likely represents the most detailed transmission spectrum of exoplanet measured to date. At different resolutions and with multiple overlapping wavelength ranges, these data enable the first one-to-one cross-comparison between JWST's near-infrared instrumental modes and are a powerful verification of their relative performance. This spectrum has also enabled an exploration of the physics and chemistry of WASP-39b through atmospheric retrieval frameworks, grids of forward models, and general circulation models. I will discuss the molecular features observed, their abundances, bulk planetary properties such as metallicity and carbon-to-oxygen (C/O) ratio, and inferences on the formation and evolutionary history of WASP-39b. In both data analysis and modeling aspects, I will also discuss the lessons learned from interpreting this new era of JWST observations, combining the expertise of different teams and analysis tools.

## Kielan K. W. Hoch

### Title: Moderate-resolution Spectroscopy of Directly Imaged Exoplanets

Direct imaging of exoplanets has revealed a population of Jupiter-like objects that orbit at large separations (~10-100 AU) from their host stars. These planets, with masses of ~2-14MJup and temperatures of ~500-2000 K, remain a mystery for the two main planet formation models—core accretion and gravitational instability. Observations that probe elemental abundances in the atmospheres of these young gas giants can shed light on their formation. I present results both from my survey of directly imaged planets with moderate resolution spectra (R~4000) using the OSIRIS IFU on the W.M. Keck I telescope, as well as my JWST Cycle 1 Program 2044 to directly image the multi-planet system TYC 8998-760-1 (YSES-1) using NIRSpec and MIRI. With OSIRIS, we observed nine companions in the K-band (2.2 um), including Kappa Andromeda b, VHS 1256 b, and HD 284149 b. The spectra reveal resolved molecular lines from water and CO, allowing for the derivation of temperature, surface gravity, metallicity, and C/O ratio. Comparing directly imaged planet C/O ratios to a uniform sample of transiting planets reveals that the C/O ratio may be correlated with mass, with two distinct groups split at 4MJup. With JWST, I am leading a program that is fundamental in pushing current direct imaging spectroscopy to longer wavelengths inaccessible from the ground. The YSES-1 spectra will be one of the most comprehensive datasets of a multi-planet system ever imaged. Pushing to longer wavelengths will better constrain C/O, non-equilibrium chemistry, and cloud composition increasing our understanding of substellar atmospheres and formation.

## Julie Inglis

### Title: A JWST MIRI Dayside Emission Spectrum of the Benchmark Hot Jupiter HD 189733 b

The benchmark hot Jupiter, HD 189733b, remains one of the best studied exoplanets to date and is a cornerstone for models of hot giant planets. Early observations with HST (Swain et al. 2008, 2009, 2014) and Spitzer (Grillmair et al. 2007, 2008) in emission uncovered some of the first evidence for the presence of multiple molecules in its atmosphere, as well as signs of disequilibrium chemistry. It was also the first planet with a measured phase curve, revealing the presence of an equatorial super-rotating jet (Knutson et al. 2007). With the launch of JWST, we now have renewed access to mid-infrared wavelengths at unprecedented spectral precision; this provides us with a new opportunity to revisit this benchmark planet's mid-infrared emission spectrum. We will present new dayside emission observations of HD 189733b with MIRI LRS and place them in context of previous observations with HST and Spitzer. We will also discuss how the exceptional precision of JWST observations of this prototypical hot Jupiter can be used to advance our understanding of the thermal structure and atmospheric chemistry of hot gas giant exoplanets.

## Jens Kammerer

### Title: Direct characterization of exoplanetary systems with JWST: lessons learnt from one year of operations

Commissioned about a year ago, JWST has readily demonstrated its ability to take beautiful pictures of exoplanets and circumstellar disks. For the first time ever, JWST can directly image exoplanets in the mid-infrared and detect companions as small as Saturn. Complementary to transit and radial velocity observations, direct imaging techniques are ideally suited to study young exoplanetary systems and JWST has shown the potential to advance the fields of planet demographics, planet migration, and planet formation. In this talk, I will present an overview of several Cycle 1 JWST ERS and GTO observations of known exoplanetary systems and explain the on-sky telescope performance for high-contrast imaging observations. I will also briefly summarize gained knowledge on best observing and data reduction practices. I will then outline how JWST can study the demographics of wide-separation analogs of the Solar System giant planets, how it can provide constraints on giant planet migration and outward scattering processes, and how it can connect observations of protoplanetary disks with dynamical modeling of these by searching for embedded protoplanets. Moreover, spectroscopic observations of young giant planets and brown dwarfs can provide complementary constraints on these objects' formation pathways, yielding a much more comprehensive picture of the origin of the wide separation companion population uncovered by direct imaging techniques.

## Erin May

### Title: Constraints on the Atmosphere of the Super-Earth GJ 1132b from JWST NIRSpec Observations

One major hurdle remains before we can begin classifying terrestrial planets as habitable - determining which, if any, host atmospheres. Of particular interest are terrestrial planets orbiting M-dwarfs, owing to their favorable planet-star size ratios. However, the increased XUV radiation in these systems may make it difficult for such worlds to hold onto their atmospheres. In this talk, we present results from a JWST Cycle 1 GO program which seeks to answer the question "what types of M-dwarf planets host atmospheres?”. We are targeting planets on both sides of the “cosmic shoreline”, a line dividing planets with and without substantial atmospheres within our Solar System. Here we present JWST NIRSpec G395H transmission spectroscopy observations of GJ 1132b, a roughly 550 K, 1.1 Earth radius planet. We present the transit spectrum derived from two transit events and constraints on the atmospheric composition from a retrieval analysis. Despite previous Hubble observations of GJ 1132b being inconclusive, the unprecedented precision of our JWST data shines a light onto the true nature of this planet’s atmosphere. Results from GJ 1132b and other targets in this program will help to determine if the cosmic shoreline hypothesis can be applied to planets outside our Solar System - specifically terrestrial planets around M-dwarfs - and if the comic shoreline is a good metric to use when identifying targets for detailed characterization in the search for biosignatures.

## Kevin Schlaufman

### Title: The Importance of High-precision Stellar Fundamental Parameter and Elemental Abundance Inferences for JWST Studies of Exoplanet Atmospheres

James Webb Space Telescope (JWST) Early Release Science and Cycle 1 observations are driving rapid progress in the study of exoplanet atmospheres. Indeed, JWST observations are making elemental abundance inferences in exoplanet atmospheres routine. We argue that the full potential of these exoplanet atmospheric abundance inferences can only be realized if they are paired with high-precision fundamental and photospheric stellar parameter and elemental abundance inferences for exoplanet host stars that are both self-consistent and physically consistent with stellar evolution. This approach is necessary because the possibly non-solar mean compositions of the parent protoplanetary disks of exoplanets are recorded in the photospheric abundances of their host stars. As an example, we show for the solar-type hot Jupiter host star WASP-77 A that a comprehensive and precise characterization of its fundamental stellar parameters and elemental abundances corrected for departures from the assumptions of local thermodynamic equilibrium qualitatively changes the interpretation of the atmospheric carbon and oxygen abundances of the hot Jupiter WASP-77 A b. The elemental abundances of WASP-77 A and WASP-77 A b jointly suggest that the planet formed beyond its parent protoplanetary disk's water ice line, possibly from pebble accretion followed by high-eccentricity migration after disk dissipation. Accounting for the possibility of tidally mediated angular momentum exchange in the WASP-77 A system resolves the tension between its isochrone- and gyrochronology-based ages and provides further evidence that in general gyrochronology-based ages should not be relied on for hot Jupiter systems.

## Jordan Stone

### Title: Thermal-IR spectroscopic probes of extincted giant protoplanets

Forming giant planets sculpt large-scale structures in the disks from which they feed and grow. These structures affect the flow of material through the disk and set the stage for subsequent planet formation. Connecting the details of disk substructures to the characteristics of the protoplanets driving their formation is the exciting goal of direct imaging programs targeting young systems. However, sophisticated hydrodynamic planet formation models suggest that extinction from circumplanetary material can reach levels of Av~200, significantly impacting the sensitivity of near-IR observations even for massive and hot protoplanets. I will report the discovery of a massive protoplanet beyond the tip of the southern spiral arm in the MWC 758 system. This protoplanet is not seen at near-IR wavelengths and our spectroscopic resolution is harnessed to show that the protoplanet has a distinct color separating it from other disk material. This work demonstrates the power of thermal infrared observations for direct probes of the planet formation process. JWST NIRCam and MIRI observations can constrain the level of extinction and break the Av-effective temperature degeneracy, resulting in better constraints of the fundamental parameters of the protoplanet.

## Astrobiology:

## Ana Glidden

### Title: Can Carbon Fractionation Provide Evidence for Aerial Biospheres in the Atmospheres of Temperate Sub-Neptunes?

The search for signs of life on other worlds has largely focused on terrestrial planets. However, characterization of terrestrial exoplanet atmospheres is observationally challenging, and near-term observations with facilities such as JWST can detect terrestrial planet bioindicators only in the most favorable scenarios. Here, we evaluate the efficacy of carbon dioxide isotopologues as indicators of aerial life in gaseous exoplanet (sub-Neptune) biospheres. Such worlds have recently been proposed as potentially habitable (Seager et al. 2021). Given their larger size, atmospheric constituents of sub-Neputnes are more readily observable than those of terrestrial planets. However, existing theories of abiogenesis predict that life would not emerge in a gaseous exoplanet. Thus, the detection of bioindicators on gaseous exoplanets would falsify existing theories of the origin of life, providing a unique opportunity to empirically test whether rocky planetary surfaces are required for abiogenesis. We focus on carbon isotopes as bioindicators as metabolic processes preferentially use the lighter $^{12}C$ over $^{13}C$. We simulated observations of $CO_2$ isotopologues in the $H_2$-dominated atmospheres of our nearest ($< 40$ pc), temperate (equilibrium temperature of 250-350 K) sub-Neptunes with M dwarf host stars. We find Earth-like fractionation of $^{13}CO_2$ and $^{12}CO_2$ to be distinguishable only if the atmosphere is $H_2$-dominated with a few percentage points of $CO_2$. As the detectability of $^{13}CO_2$ is only possible in the most idealized case, carbon dioxide isotopologues are unlikely to be useful biosignature gases in the JWST era. Instead, isotopologue measurements should be used to evaluate formation mechanisms of planets and exoplanetary systems.

## Kenneth Gordon

### Title: Differentiating Terrestrial Exoplanet Archetypes with Polarized Reflected Light

In the JWST and Extremely Large Telescopes (ELTs) era, we expect to characterize a number of terrestrial exoplanets. Although JWST will allow for numerous follow-up characterizations of transiting planets, debate still exists on the feasibility of the telescope to effectively characterize lower-mass terrestrial exoplanets in the habitable zones around FGK stars. Additionally, current characterization methods only use the unpolarized flux from these worlds, taking into account only 33% of the reflected light. Polarimetry, however, uses 100% of the light and is extremely sensitive to the physical and microphysical properties of the planet that are causing the scattering of the light. To assist JWST and other observatories in their characterizations of terrestrial exoplanets, we present preliminary models of unpolarized and polarized reflected light from planets with a range of atmospheric and surface properties, including Archean, Proterozoic, and modern Earth; modern Venus; two Super-Earths; and rocky and aqua planets with thin clear atmospheres. We show that the contributions from the different surfaces, clouds, and atmospheres affect the resulting planetary phase curves and make it possible to differentiate the potentially habitable planets from the non-habitable scenarios. Our aim is to provide the community with a suite of unpolarized and polarized light models spanning a wide range of terrestrial exoplanetary conditions. Analyses of the different models in this suite will allow for constraints to be made on the variety of levels of flux and polarization for these worlds, therefore providing useful predictions for upcoming polarimeter designs and observing plans by ground and space-based observatories.

## Susana Iglesias-Groth

### Title: Evidence for amino acids in the gas of the star-forming region IC 348

Amino acids are present in carbonaceous chondrite meteorites and comets, but their origin is still unknown. Formation in the interstellar medium is posible via specific gas-phase reactions in dark clouds, however sensitive searches at millimeter wavelengths have not revealed their existence yet. The mid-IR vibrational spectra of amino acids provides an alternative path for their identification. We present Spitzer spectroscopic observations in the gas of the very young star cluster IC 348 of the Perseus Molecular Cloud showing evidence for mid-IR bands of H2, OH, H2O, CO2, C2H2, C4H2, HC5N, C2H6, C6H2, C6H6, PAHs, fullerenes C60 and C70 and emission lines consistent with the most intense laboratory bands of the three aromatic amino acids, tyrosine, phenylalanine and tryptophan and the aliphatic amino acids isoleucine and glycine. JWST may provide higher sensitivity and higher dispersion data to confirm or disprove these results. Preliminary estimations of column densities give values 10-100 times higher for isoleucine and glycine than for the aromatic amino acids as in some meteorites. The strongest bands of each amino acid are also found in the combined spectrum of >30 interstellar locations in diverse star-forming regions supporting that amino acids could be widely spread in interstellar space. Future mid-IR searches with JWST for proteinogenic amino acids in protostars, protoplanetary disks and in the interstellar medium will be key to establish an exogenous origin of meteoritic amino acids and to understand how the prebiotic conditions for life were set in the early Earth.

## Thaddeus Komacek

### Title: Characterizing the atmospheric composition and climate of potentially habitable exoplanets in the era of JWST

The advent of JWST has enabled the first broadband spectroscopic studies of rocky exoplanets in the infrared. Importantly, JWST will provide an opportunity to constrain the atmospheric composition of rocky exoplanets that lie within the habitable zones of late-type M dwarf stars. However, such observational characterization via transmission spectroscopic may be formidable due to challenges associated with stellar activity, atmospheric loss, and high-altitude aerosols. In this talk, I will discuss recent efforts to determine the extent that clouds impact the transmission spectra of temperate rocky exoplanets orbiting M dwarf stars. To simulate the impact of clouds on the climate state and observable properties of rocky exoplanets, we use the ExoCAM GCM post-processed with the Planetary Spectrum Generator (PSG) Global Emission Spectra (GlobES) radiative transfer code. I will present simulated transmission spectra both for idealized systems of rocky exoplanets orbiting M dwarf stars, as well as the best habitable zone candidate for characterization with JWST NIRSpec/PRISM, TRAPPIST-1e. We find that cloud coverage does not prevent detection of both the key habitability indicator water vapor as well as the potential carbon dioxide-methane biosignature pair in the atmosphere of TRAPPIST-1e over the nominal lifetime of JWST. Additionally, we find that the impact of climate variability on transmission spectra does not affect the detectability of spectral features in TRAPPIST-1e with JWST NIRSpec/PRISM.

## Katie Teixeira

### Title: Modeling the Evolution of TRAPPIST-1c's Atmosphere Through Outgassing and Escape

With the successful deployment of JWST, and its aim to potentially search for biosignatures on exoplanets, an important endeavor, at present, is to determine whether the rocky planets we observe are likely to have atmospheres at all. M dwarfs, the main host stars of JWST's rocky planet targets, are thought to pose a major threat to planetary atmospheres due to their high magnetic activity over several billion-year timescales, and might completely strip atmospheres. Several Cycle 1 GO programs are testing this hypothesis, observing some of the most interesting rocky planets that we know, e.g., the TRAPPIST-1 system. An interesting case-study is TRAPPIST-1c, which receives almost the same bolometric flux as Venus. We might, therefore, expect TRAPPIST-1c to possess a thick, CO2-dominated atmosphere. Instead, recent observations show that TRAPPIST-1c potentially has trace amounts of CO2 in its atmosphere. We need physical models to explain these results, to understand how a planet's atmosphere evolves to become what we see today. Here, I will present coupled time-dependent simulations of planetary outgassing and atmospheric escape, processes that most influence atmospheric composition, that model the evolution of TRAPPIST-1c's atmosphere. I will discuss the results of the simulations, specifically the constraints that they place on the history of TRAPPIST-1c's atmosphere. I will describe the most likely range of planetary properties of TRAPPIST-1c, including initial carbon budget and radiogenic heat element budget, that agree with observations. Finally, I will discuss how this work can be expanded to model different physical phenomena and more potentially habitable planets.

# Poster Abstracts

## Nick Ballering

### Title: Simulating Protoplanetary Disk Ices

Abstract: New observations with powerful infrared facilities, most notably JWST, will reveal the spectral signatures of ices in protoplanetary disks in unprecedented detail. The diversity, abundance, and distribution of disk ices play vital roles in planet formation and the delivery of biocritical volatiles to planets. Disks are physically and chemically heterogeneous, so inferring the ice properties from observations is non-trivial. I will present results from an ongoing program to forward-model disk ice spectral features, providing a powerful tool to fully understand the ice reservoirs probed by observations. The models use a kinetics-based gas-grain chemical evolution code to simulate the distribution of ices in a disk, followed by radiative transfer using a subset of key ice species to simulate the observations. I will discuss which ice species should be detectable and how the observable features vary with system properties, including stellar type, disk inclination, inheritance vs. reset initial chemical conditions, and subsequent chemical evolution. I will also highlight the value of obtaining spatially resolved spectra of edge-on disks (possible with, e.g., JWST's integral field units) to constrain the vertical distribution of ices.

*Theme: Protoplanetary/Debris Disks*

## Ell Bogat

### Title: A JWST NIRCam Coronagraphic Imaging Survey of Nearby, Young M Dwarfs: Preliminary Results

Abstract: The population of giant planets on wide orbits around low-mass M dwarf stars is poorly understood. However, the discovery and characterization of these planets is key to understanding the architectures and evolution of M dwarf planetary systems and places their frequent and potentially habitable inner planets in context. While current ground based imaging struggles to probe below a Jupiter mass at large separations, the unprecedented sensitivity of JWST NIRCam coronagraphic imaging provides direct access to planets significantly less massive than Jupiter beyond 10 AU around the closest, youngest M dwarfs. Here we present the survey design, sensitivity limits, and early results of JWST GTO Program 1184, a NIRCam coronagraphic imaging survey of very nearby young low-mass stars.

*Theme: Exoplanets/Brown Dwarfs*

## Bryce Bolin

### Title: The Volatile Content of the giant Oort Cloud Comet C/2014 UN271

Abstract: Oort Cloud comets are remnants of the original planetesimals that were ejected from the planetary region in the late stages of planetary formation. The Oort Cloud comet C/2014 UN271, hereafter UN271, is ~140 km in diameter, large enough that it could be an intact planetesimal that formed in the protoplanetary disk before being ejected into the Oort Cloud. Given UN271's large heliocentric distance of ~20 au, it is likely that its activity is driven by hypervolatiles such as CO or CO2 and not H2O. UN271 is on its first inbound trip to the Solar System's planetary region providing the rare opportunity to study the volatile contents of one of the original planetesimals in a pristine state. We propose NIRSpec IFU observations of UN271 covering the spectral range where vibrational bands of gas-phase hypervolatiles (such as CO/CO2) and solid-phase water-ice grains can be detected. Our observations will provide constraints on the comet's CO and CO2 production rates, the activity driving mechanism, and the presence and nature of water-ice grains in its coma. The detection of volatiles and constraints on the activity of the largest known Oort Cloud comet and one of the original planetesimals will be tremendously exciting and useful for placing constraints on the volatile contents and timing of the formation of the original planetesimals. These observations will be combined with observations from HST to maximize the science of both datasets spanning the visible and NIR.

*Theme: Solar System/Extrasolar Minor Bodies*

## Aarynn Carter

### Title: The First Images of an Exoplanet with JWST

Abstract: Our Early Release Science program: "High Contrast Imaging of Exoplanets and Exoplanetary Systems" (ERS-1386) recently conducted the first direct imaging observations of an exoplanet with JWST. In this talk, I will present the results from the first publication from this collaboration, which focuses on NIRCam and MIRI coronagraphic observations of the super-Jupiter mass exoplanet HIP 65426b from 2-16 µm. Unaffected by the detrimental effects of Earth's atmosphere, these data reach unprecedented precisions across this wavelength range, and represent the first time an exoplanet has been directly imaged beyond 5 µm. Access across this broad wavelength range at high precision has significant implications for our ability to measure the bulk and atmospheric properties of exoplanets, and enables powerful intercomparisons between predictions from atmospheric and evolutionary models. Furthermore, as the first on-sky scientific demonstrations of their kind, I will discuss how these observations illuminate the true capabilities of JWST coronagraphic imaging. With an overall improvement compared to pre-launch predictions, JWST direct imaging presents a unique opportunity for the further study of exoplanets discovered through direct imaging, as well as the first exploration of the sub-Jupiter mass exoplanet population.

*Theme: Exoplanets/Brown Dwarfs*

## Brandon Park Coy

### Title: How JWST MIRI Will Improve upon Spitzer IRS Observations of Titan

Abstract: We present, for the first time, infrared spectra of Titan from the Spitzer Space Telescope InfraRed Spectrograph (IRS, 2004−2009). The data are from both the short wavelength-low resolution (5.13−14.29 μm, 1950 – 700 cm-1, R∼60−127) and short wavelength-high resolution (9.89−19.51 μm, 1011 – 512 cm-1, R∼600) channels and include thermal emission of $CH_4$, $C_2H_2$, $C_2H_4$, $C_2H_6$, $C_3H_4$, $C_3H_6$, $C_3H_8$, $C_4H_2$, HCN, $HC_3N$, and $CO_2$. We also identify several candidate features in the 16.35−19.35 μm (610 – 517 cm-1) range which could indicate new bands of known molecules or molecules previously undetected on Titan. Our data adds new constraints to the haze spectrum from 16.4-17.9 μm (560 – 610 cm-1) which has been previously poorly constrained due to noise in data from the Cassini Composite InfraRed Spectrometer (CIRS). We discuss how existing spectral databases, like the NASA PAH IR Spectral Database, may be used to provide fits to the haze spectrum. We then show how scheduled Cycle 1-GO observations with the James Webb Space Telescope Mid-Infrared Instrument (JWST/MIRI, 5.0−28.3 μm, 2000—353 cm-1) at higher spectral resolution should improve upon the current measurements. This is especially true from 16.35−19.35 μm, where IRS suffered from low spectral resolution and CIRS suffered from high noise levels. Increases in resolving power (R∼1500−3500) and sensitivity (20~70 x that of IRS) with MIRI will allow for improved molecular detection capabilities. We conclude by highlighting specific laboratory and theoretical measurements that would address current gaps in the knowledge of molecular spectra relevant to Titan.

*Themes: Minor Bodies (Solar System or Extrasolar), Astrobiology*

## John Debes

### Title: Characterizing the Planetary System around WD 0141-675

Abstract: White dwarf pollution provides a novel way to characterize the chemical abundance of rocky material present around remnant planetary systems. A key open question is where these reservoirs of material reside and how their locations might change over the course of stellar evolution. We present a detailed spectroscopic and abundance analysis of the unique candidate white dwarf astrometric planet host WD 0141-675, which also shows evidence of pollution. We have determined a bulk accretion rate of the material, a likely abundance, and limits to emission from the planetary companion. We investigate what might be the source of the pollution: accretion from the companion or from rocky minor bodies. Dynamical simulations show that minor body accretion is possible but difficult with a close planetary companion. We also make predictions for how much infrared emission the companion may have in the mid-IR with JWST, which will help to constrain its age relative to the total age of the white dwarf and constrain the history of the planet and the minor bodies present in the system.

*Themes: Minor Bodies (Solar System or Extrasolar), Exoplanets/Brown Dwarfs*

## Laurence Denneulin

### Title: JJWST/NIRSpec Fixed Slit spectra of 2003 AZ84

Abstract: Observations of Plutino 2003 AZ84 suggest it could share similar properties to Orcus, or even Pluto's satellite Charon. Because it is smaller, hence fainter, its surface composition could not be constrained from ground-based spectroscopy. The JWST/NIRSpec instrument was thus used to target 2003 AZ84, using the Fixed Slit (FS) mode, with both low and medium spectral resolutions, from 0.6 to 5.3 microns. To avoid any loss of spectral information, an optimal processing of these FS data is necessary. In this work, we propose such an optimal spectra extraction method, using an inverse problem approach. For each wavelength, the data acquired on the detector are considered as a 1D spatial Point Spread Function (PSF), with the amplitude giving the spectral value for this wavelength. A thorough model of the spatial PSF is thus essential to ensure the optimal processing. The spectrum is then extracted by minimizing the co-log-likelihood of the data, with an additive regularization term, to avoid noise amplification in the extraction. We present the results of our method for the spectra extraction of 2003 AZ84, and compare them to the spectra obtained with the JWST/NIRSpec pipeline, where the spectrum is extracted by integrating the flux in fixed size small aperture.

*Theme: Solar System/Extrasolar Minor Bodies*

## Kate Follette

### Title: Direct Observational Constraints on Planet Formation and Accretion

Abstract: We are entering an exciting era where it is possible to directly observe the assembly of giant planets, both through detection and characterization of forming protoplanets and through high-resolution, high-contrast imaging of the circumstellar and circumplanetary environments in which they form. I will describe our recent progress in detecting and vetting protoplanet candidates, which requires robust techniques for separating planetary emission from that of the surrounding morphologically-complex circumstellar disk. I will also describe our recent multiwavelength ground and space-based efforts to characterize protoplanets and young, accreting brown dwarfs. These efforts have the goal of informing the properties of protoplanets on a population-level and speak strongly to the promise of JWST for informing accretion physics and disentangling planet formation pathways .

*Themes: Protoplanetary/Debris Disks, Exoplanets/Brown Dwarfs*

## Guangwei Fu

### Title: Constraints on the Presence of a Rocky Exoplanet Atmosphere from a JWST Transmission Spectrum

Abstract: The critical first step in the search for life on exoplanets over the next decade is to determine whether rocky planets transiting small M dwarf stars possess atmospheres and, if so, what processes sculpt them over time. Because of its broad wavelength coverage and, improved resolution compared to previous methods, spectroscopy with JWST offers a new capability to detect and characterize the atmospheres of Earth-sized, M-dwarf planets. Here we use JWST to independently validate the discovery of LHS 475b, a warm (586 K), 0.99 Earth-radius exoplanet, interior to the habitable zone, and report a precise 2.9 − 5.3 μm transmission spectrum. With two transit observations, we rule out primordial hydrogen-dominated and cloudless pure methane atmospheres. Thus far, the featureless transmission spectrum remains consistent with a planet that has a high-altitude cloud deck (similar to Venus), a tenuous atmosphere (similar to Mars), or no appreciable atmosphere at all (akin to Mercury). There are no signs of stellar contamination due to spots or faculae. Our observations demonstrate that JWST has the requisite sensitivity to constrain the secondary atmospheres of terrestrial exoplanets with absorption features < 50 ppm, and that our current atmospheric constraints speak to the nature of the planet itself, rather than instrumental limits

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Eric Gaidos

### Title: Only a Matter of Time: Ages of M Dwarf Stars and their Planets for Better Astrobiology

Abstract: Earth's atmosphere has evolved over billions of years, driven by changes in solar luminosity, rates of mantle convection and crust formation, exchange of light elements between the atmosphere and interior, escape of hydrogen to space, and life. Rocky planets in the habitable zones around other stars presumably experience analogous evolution, but with varying tempo and pattern depending on the host star's properties, planet's orbital semi-major axis, mass and composition, and presence or absence of a biosphere. Correct temporal ordering of planets observed by JWST and proposed future observatories would allow such evolution and its pace to be investigated. The ages of planets are estimated by age-dating their parent stars, and the great majority of known temperate rocky exoplanets, and the most observationally accessible, orbit M-type dwarf stars. I describe recent work to more rigorously estimate the ages of late K and early M dwarf stars using stellar rotation (gyrochronology). That calibration has recently been extended to 4 Gyr, almost to the mid-point of the history of the Galactic disk. The time-rotation period relation at late times is consistent with the simple power-law relation originally predicted by Skumanich, suggesting that it can be extended to yet older stars. I describe how this gyrochronology will be improved in the future and how age assignments can be used to investigate evolution of atmospheres and, possibly, the appearance of biospheres, among samples of planets.

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Ana Glidden

### TItle: Constraining Atmospheric Scenarios of TRAPPIST-1 e with Simulated JWST Observations

Abstract: The launch of JWST has opened the era of atmospheric characterization of potentially habitable exoplanets. Observations of the nearby temperate terrestrial exoplanets around TRAPPIST-1 have already begun. Here, we report on forward modeling work conducted in preparation for JWST GTO Exoplanet Transit Spectroscopy team observations of TRAPPIST-1 e (PI: N. Lewis). We have performed a model comparison exercise between petitRADTRANS (Mollière et al. 2019), PICASO (Batalha et al. 2019), and POSEIDON (MacDonald 2023), identifying and harmonizing causes for disagreement. We have combined our simulated spectra with JWST noise simulations (PANDEXO; Batalha et al. 2017) and compared our noise model with the observed uncertainty from JWST observations of TRAPPIST-1 g. The four transits in our GTO Program will permit initial reconnaissance of TRAPPIST-1 e's atmosphere, though a close consideration is required for which atmospheric scenarios we will be able to support or reject with our expected data. We will be able to evaluate specific atmospheric compositions such as a low mean molecular weight, primordial H$_{2}$/He-dominated atmosphere, and the presence of strong absorbers, such as CO$_{2}$ and CH$_{4}$. We further consider a suite of atmospheric scenarios for TRAPPIST-1 e, including ``abiotic Earth-like”, massive atmospheres (H$_{2}$, O$_{2}$, N$_{2}$-N$_{2}$ CIA, N$_{2}$-CO$_{2}$ CIA, etc.), large O$_{2}$ (from escape, buildup), and photochemical runaway (e.g, Zahnle 1986; Kasting 2014, Lustig-Yaeger et al. 2019; Ranjan et al. 2022).

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Yinuo Han

### Title: Is the dust clump in the debris disk of Beta Pictoris moving?

Abstract: Beta Pictoris hosts one of the most iconic and well-studied debris disks within a planetary system and is scheduled to be observed by JWST (GTO programs 1241, 1411). Despite the wealth of observational and theoretical studies, the nature of a prominent clump of dust and gas in the disk at ~50 au from the star remains uncertain. Such a significant brightness asymmetry is rarely witnessed in other debris disks and it could hold important clues for understanding certain interactions between planets and disks. In this talk, I discuss recent results from studying multi-epoch mid-infrared imaging which constrain the displacement of the dust clump. These constraints show that the clump is likely stationary, disfavoring scenarios such as resonant planetesimals due to a perturbing planet in which the clump is expected to move. Other scenarios such as a giant impact may produce a stationary dust clump, however these scenarios come with their own challenges and interesting implications. It must also be acknowledged that the proper motion constraints cannot completely rule out stationary dust clump scenarios such as resonance with a planet, and the upcoming JWST observations will offer important constraints both by imaging the disk structure and by detecting or setting limits on perturbing planets. I will discuss what current observations mean under different theories explaining the origin of the clump, predictions on the presence and properties of any planets involved, and how the upcoming JWST observations will further constrain or even rule out theories.

Themes: Protoplanetary/Debris Disks, Exoplanets/Brown Dwarfs

# Bryan Holler

## Title: Constraining the origins of TNO binaries through resolved spectroscopy

Abstract: The various dynamical classes in the trans-Neptunian region record the history of Neptune's migration early in solar system history. The low-inclination, low-eccentricity cold classical objects are thought to be the remnants of the outer primordial disk of minor bodies, left undisturbed by the migration of Neptune, while all other classes were implanted on their current orbits from smaller heliocentric distances through interaction with Neptune. Many other trans-Neptunian objects (TNOs) were lost from the solar system entirely or transferred onto crossing orbits that resulted in collisions. Not unexpectedly, two very different populations of TNO binary systems are observed: (1) large TNOs with small satellites on relatively tight orbits and (2) small TNOs, mostly cold classicals, with roughly equal-sized components and relatively large separations. This stark contrast points to two very different formation mechanisms—giant impacts and co-formation—and corresponding expectations for the compositions of the components. Giant impacts are more likely to result in different compositions for the primary and secondary, while co-formation implies similar compositions. Observations with the JWST NIRSpec IFU provide sufficient spatial resolution to resolve TNO binaries and sufficient sensitivity to obtain spectra of both components. We have examined data for both large and small TNO binaries from GTO and GO programs and present spectral comparisons of the primaries and secondaries. The results of this work have implications for the early dynamical history and collisional environment in our own outer solar system, with links to other planetary systems with observed debris disks.

*Themes: Minor Bodies (Solar System or Extrasolar), Solar System (Large scale/Planetary System)*

# Jingcheng Huang

## Title: Assessment of Ammonia as a Biosignature Gas in Exoplanet Atmospheres

Abstract: We study NH3's biosignature potential in a terrestrial planet's atmosphere. Although terrestrial planets have no significant known abiotic NH3 source, we find that the conditions required for NH3 to accumulate in the atmosphere are stringent. NH3's high water solubility and high bio-useability likely prevent NH3 from accumulating in the atmosphere to detectable levels unless life is a net source of NH3 and produces enough NH3 to saturate the surface sinks. For the highly favorable planetary scenario of terrestrial planets with H2-dominated atmospheres orbiting M dwarf stars, we find a minimum of about 5 ppm column-averaged mixing ratio is needed for NH3 to be detectable with JWST, considering a 10 ppm JWST systematic noise floor. When the surface is saturated with NH3 (i.e., there are no NH3-removal reactions on the surface), the required biological surface flux to reach 5 ppm is on the order of 1010 molecules cm-2 s-1, comparable to the terrestrial biological production of CH4. However, when the surface is unsaturated with NH3, due to additional sinks present on the surface, life would have to produce NH3 at surface flux levels on the order of 1015 molecules cm-2 s-1 (~4.5×106 Tg year-1). This value is roughly 20,000 times greater than the biological production of NH3 on Earth and about 10,000 times greater than Earth's CH4 biological production. Finally, to establish NH3 as a biosignature gas, we must rule out mini-Neptunes with deep atmospheres, where temperatures and pressures are high enough for NH3's atmospheric production.

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Michael Kelley

### Title: Where do comets fit in the astrophysical puzzle?

Abstract: Comets are one of our most direct links to the conditions present in the early Solar System. They have retained volatiles with ice sublimation temperatures as low as ~20 K, not only indicating that they formed in cold regions of the solar system's protoplanetary disk, but also that they have remained cold over the 4.5 Gyr history of the solar system. However, an examination of the cometary population reveals characteristics that suggest their present-day compositions are affected by thermal processes. An excellent example of these characteristics can be found in the short-period comet 22P/Kopff. We present JWST/NIRSpec IFU spectroscopy of comet Kopff, and discuss the data in the context of the three primary volatiles in the cometary population: water, carbon dioxide, and carbon monoxide. Compared to water, comet Kopff is depleted in CO, similar to many other short-period comets. In contrast, the CO2-to-H2O ratio is typical for a comet of any type (short- or long-period), but the spatial distributions of these gases as observed with JWST indicate that they originate from distinctly different regions on the nucleus. Therefore, the ratio CO2/H2O measured in the coma reflects the composition of a heterogeneous surface, rather than that of the bulk nucleus. We discuss how sunlight-driven processes can reproduce these aspects of comet Kopff and others. With respect to the three primary cometary volatiles, proto-planetary disk studies can be used to inform the studies of comets, and comets provide a local analog to circumstellar debris disks.

*Theme: Minor Bodies (Solar System or Extrasolar)*

## Joshua Lothringer

### Title: Uncovering the Origins of Planetary Systems through Ultra-hot Jupiters

Abstract: To understand the formation and evolution of planets light-years away, we must look for clues in their atmospheres. I will first explore how the measurement of elemental abundances in exoplanets through panchromatic atmospheric characterization is revealing the story of planetary birth and migration. In particular, the population of ultra-hot Jupiters are irradiated enough to vaporize refractory material, opening a new window into giant planet formation through the first measurements of rock-to-ice ratios. Combined with the C/O ratio, a detailed understanding of the origin of giant planets can begin to be revealed. I will highlight results from some of the first JWST observations of these ultra-hot planets, including the measurement of WASP-178b's refractory-to-volatile and C/O ratios. I will also highlight how other important atmospheric processes, like cloud formation, can be understood through ultra-hot Jupiters.

*Theme: Exoplanets/Brown Dwarfs*

## Gary Melnick

### Title: SPHEREx Investigation of Ices Throughout the Milky Way

Abstract: SPHEREx, the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer, is an approved NASA Medium-Class Explorer mission designed to: (1) investigate the distribution and abundance of water and other key molecular ices in interstellar clouds, young stellar objects, and protoplanetary disks throughout the Milky Way; (2) constrain the physics of inflation by measuring the three-dimensional distribution of more than three hundred million galaxies; and, (3) explore the origin and evolution of galaxies through a deep multi-band measurement of large-scale clustering. To achieve these goals, SPHEREx will obtain 0.75 to 5.0 µm spectra within every 6.2 x 6.2-arcsecond region over the entire sky, or a total of 13.9 billion spectra. It implements a simple instrument design with a single observing mode to map the entire sky four times during its baseline 25-month mission. Launch is expected in 2025. This talk will describe our plans to use SPHEREx to complement the various JWST ice investigations through the acquisition of more than 8 million ice absorption spectra across the Milky Way. Beyond obtaining a statistically significant number of ice spectra toward clouds at all evolutionary stages – from diffuse clouds to protoplanetary disks – SPHEREx will both benefit from the wisdom gained from more than 2 years of JWST ice observations and, through its extensive survey, will identify interesting lines of sight for follow-up study with JWST.

*Themes: Protoplanetary/Debris Disks, Astrobiology*

## Sagnick Mukherjee

### Title: PICASO: An Unified Atmospheric Model of Exoplanetary Atmospheres with Photochemistry and Vertical Mixing

Abstract: The first JWST observations of exoplanetary atmospheres have already shown that processes causing disequilibrium chemistry, such as vertical mixing and photochemistry, are extremely important. Apart from being poorly understood, they are already identified as important pathways to probe the interiors and formation pathways of exoplanets. However, to effectively use these processes as probes of deep exoplanetary atmospheres and interiors in the JWST era, they need to be physically understood first, which requires more sophisticated atmospheric models than what is available today. We have developed PICASO 3.0, which is an open-sourced atmospheric model for exoplanets and brown dwarfs and includes the capability to capture vertical mixing-induced quenching of gases (e.g., CO and $CH_4$) self-consistently. However, PICASO, like other models, used to ignore key atmospheric processes such as photochemistry and molecular diffusion, which are known to have large effects on the atmospheric chemistry of exoplanets. We have upgraded PICASO by coupling it with the chemical network code VULCAN, which has allowed us to model the effects of vertical mixing, photochemistry, and molecular diffusion in exoplanetary atmospheres self-consistently. Using this state-of-the-art model, we have explored the impact of these processes on the thermal structure, transmission spectra, and emission spectra of warm $H_2$-He dominated atmospheres across a large range of the atmospheric mixing parameter ($K_{zz}$), interior temperature, metallicity, and carbon-to-oxygen ratio. As this model is open-sourced and well-documented, it serves as an important resource for the whole community for modeling JWST observations of transiting exoplanets and brown dwarfs.

*Theme: Exoplanets/Brown Dwarfs*

## Matthew Nixon

### Title: Three-dimensional atmospheric retrieval of exoplanets

Abstract: Atmospheric retrievals of exoplanet transmission spectra allow constraints on the composition and structure of the day-night terminator region. Such retrievals in the past have typically assumed one-dimensional temperature structures which were adequate to explain past observations using facilities such as HST. However, the significantly improved data quality from JWST motivates considerations of multidimensional atmospheric retrievals. We therefore present a three-dimensional atmospheric retrieval framework for exoplanet transmission spectra. This framework includes a forward model that enables rapid computation of transmission spectra in 3D geometry for a given atmospheric structure, which can be used for atmospheric retrievals as well as for computing spectra from General Circulation Models (GCMs). In order to efficiently explore the space of possible 3D temperature structures in retrievals, we develop a parametric 3D pressure-temperature profile which can accurately represent azimuthally-averaged temperature structures of a range of hot Jupiter GCMs. We apply our retrieval framework to simulated JWST observations of hot Jupiter transmission spectra, obtaining accurate estimates of the day-night temperature variation across the terminator as well as the abundances of chemical species. We demonstrate an example of a model hot Jupiter transmission spectrum for which a traditional 1D retrieval of JWST-quality data returns biased abundance estimates, whereas a retrieval including a day-night temperature gradient can accurately retrieve the true abundances. Our forward model also has the capability to include inhomogeneous chemistry as well as variable clouds/hazes. This new retrieval framework opens the field to detailed multidimensional atmospheric characterisation using transmission spectra of exoplanets in the JWST era.

*Theme: Exoplanets/Brown Dwarfs*

## Carlos Ortiz Quintana

### Title: The Surface Temperature of Rocky Planets

Abstract: Surface temperature is a critical aspect for assessing the habitability of Earth-like planets. This temperature is determined by various factors such as albedo and greenhouse. The data collected from the JWST and upcoming space telescopes, such as the Habitable Worlds Observatory, would be crucial for constraining surface temperatures. In this study, we modeled the mean global surface temperature of Earth-like planets using for calibration the paleotemperatures of Earth in the last 750 million years. The model considers factors such as the distribution of different types of surface fractions (e.g., vegetation, ice, desert, ocean, and clouds), Bond albedo, and greenhouse effect. The model was fitted to theoretical and experimental data from paleotemperatures and satellite data using a Markov chain Monte Carlo (MCMC) analysis. Our results showed that changes in albedo due to variations in land-ocean ratios only led to a ± 2°C change from the current mean global temperature of 15°C. An Earth-like planet, with a similar stellar flux and atmospheric composition as Earth, should have a normalized greenhouse of 0.3 to 0.5 to support temperate conditions. We also defined a new planetary property, the "thermality," which conveniently relates surface temperatures to stellar flux and other atmospheric properties. We found that the thermality of the Earth during the Phanerozoic was fairly constant, albeit the changes in albedo and greenhouse conditions. Our model can be used to constrain the mean global surface temperature of rocky planets, such as those in the TRAPPIST-1 system, based on JWST observations.

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Polychronis Patapis

### Title: The mid-infrared window for gas giant atmospheres is open! What have we found?

Abstract: The medium resolution spectrometer on board JWST/MIRI provides for the first time the opportunity to study gas giant exoplanet and brown dwarf atmospheres in the mid-infrared in great detail. We show how the molecular inventory of the atmosphere can be probed by the MRS, and allow for the precise measurement of elemental abundance ratios such as C/O but most uniquely for cold objects N/O and the isotopologue ratio of 15N/14N. These ratios connect to formation processes and open the door to new observational comparisons with solar system objects. For warmer planets, and brown dwarfs, the silicate feature between 8-12 microns provides crucial information about the presence of clouds, which need to be accounted for when estimating the bulk properties of the atmosphere. With half a dozen cool brown dwarfs and warm exoplanets having been observed, we summarise the first wave of findings, looking towards an exciting future of atmospheres with the MRS.

*Theme: Exoplanets/Brown Dwarfs*

## Jayshil A. Patel

### Title: Is it raining lava in the evening on 55 Cnc e?

Abstract: Ultra-short period planets are a unique class of planets orbiting their host star in less than a day and hence subject to intense radiation from the host star. These planets are interesting targets for studying the formation, atmospheric evolution and other interesting effects arising from strong irradiation. 55 Cnc e is one such planet orbiting a nearby bright star. This planet shows variable occultation depths, i.e., variable amounts of dayside emission. Despite being observed many times in past with Spitzer, CHEOPS and other ground-based telescopes, the origin of the variability is not well understood. Several hypotheses like atmospheric properties or volcanic activity on the surface have been invoked to explain the variability. The variability could originate from the planet being in 3:2 spin-orbit resonance and thus showing different sides during occultations. The asynchronous rotation would produce a magma pool and mineral vapors, possibly of SiO (by vaporizing $SiO_2$), on the dayside even in the absence of an atmosphere for an asynchronously rotating planet. The SiO can recrystallise back to $SiO_2$ in the evening to rain out. To test this hypothesis, we obtained 4 eclipse observations (3 during November 2022 and 1 planned for March 2023) with NIRCam/JWST (PI: Brandeker). These observations would help in constraining both long and short-term variability of emissions from the planet. I will present the first results from this analysis and its interpretation, which suggests the presence of short-term variability. I will also present the instrument performance for our multi-visit observations.

Theme: Exoplanets/Brown Dwarfs

## Cristina Thomas

### Title: NIRCam Observations of the Didymos-Dimorphos System Following the DART Kinetic Impact

Abstract: NASA's DART (Double Asteroid Redirection Test) impacted Dimorphos, the secondary of the near-Earth binary asteroid (65803) Didymos, on September 26, 2022, in the first test of kinetic impact for asteroid deflection. Telescopes around the world and in space monitored the Didymos-Dimorphos system before, during, and after the impact to study the evolution of the ejecta. JWST observed the Didymos system with NIRCam over a period of approximately 5 hours before and after impact. The successful Didymos impact observations used non-sidereal tracking at a rate greater than three times (~110 mas/sec) the then-nominal JWST tracking rate of 30 mas/s. These observations show the evolution of the ejecta near the asteroids in the hours after impact with a resolution of ~1.7 km/pixel on the short wavelength detector. A second set of NIRCam observations taken on December 9 show the state of the ejecta closest to Didymos and Dimorphos at that time (short wavelength resolution ~4.1km/pix). We will discuss the results of our JWST observations and compare our results to other imaging within our DART collaboration. Our analysis of this dataset will shed light on the early stages of ejecta evolution, collisional processes in the Solar System, and the processes that lead to the "activation" of asteroids. The ejecta particle sizes and the observed structure will provide insight into the internal structure of Dimorphos and the satellite's formation.

*Theme: Minor Bodies (Solar System or Extrasolar)*

## Nicole Wallack

### Title: Investigating the Atmosphere of the Mini-Neptune TOI-836.01: First Results from the Compositions of Mini-Planet Atmospheres for Statistical Study (COMPASS) JWST Program

Abstract: Previous observations, primarily from the Kepler space telescope, have shown that planets between the sizes of the Earth and Neptune are the most common in the Galaxy, seemingly bridging the gap between the types of planets in our own Solar System. Therefore, it is of great interest to understand how these planets formed, which we can investigate via their present-day compositions. However, thus far, the atmospheric compositions of these planets have mostly remained a mystery due to observational limitations. Now that we are firmly in the era of JWST, we can begin to measure, in more detail, the atmospheres of these planets to better understand their evolutionary trajectories. Motivated by this opportunity, we designed COMPASS (Compositions of Mini-Planet Atmospheres for Statistical Study), a JWST program to rigorously compare the presence and compositions of atmospheres for these small planets, and the largest Cycle 1 GO program dedicated to the study of exoplanet atmospheres. Here we present results from the NIRSpec G395H transmission observation of TOI-836.01, the first of 12 super-Earth/sub-Neptune planets that will be observed in transmission with the same instrument configuration and analyzed as part of the COMPASS program. TOI-836.01 (2.59 Earth radii, 9.6 Earth masses, 665 K) is also in a multi-planet system with another small planet that will be analyzed as part of our program. Although these results represent one planet examined individually, our ultimate goal is to begin to characterize the chemical diversity of these small planets at the population-level by using the entire COMPASS sample.

*Theme: Exoplanets/Brown Dwarfs*

## Alycia Weinberger

### Title: The structure of zodiacal dust around Epsilon Eri

Abstract: The Large Binocular Telescope Interferometer (LBTI) - HOSTS survey found inner warm dust around Epsilon Eridani at the level of 0.5% of the stellar photosphere, corresponding to ~300 times the solar system's zodiacal dust level. This disk has a well-known outer ring at 70 au and previously observed infrared emission inside this cold belt. Eps Eri also has a planet at ~3.4 au with an inclination similar to the outer belt. We present a detailed analysis of the warm dust observed with LBTI. Our detection of mid-infrared excess provides clear evidence for dust orbiting within 2 au of the star. Surprisingly, the disk flux increases further from the star; it is best fit with a rising surface brightness from 0.2 - 2 au. This is in contrast to the distribution of the zodiacal dust and to predictions from models that bring dust in from an outer belt with Poynting-Robertson drag. Two linked questions of interest are why the dust distribution is unlike that expected from drag and what constraints this places on the planet(s) in the system. If the planet has a substantial eccentricity, as has been suggested by astrometric results, the size of this inner dust belt restricts the eccentricity to <0.4. If the planet filters dust dragged in from the outer belt, then a substantial population of disintegrating comets or a recent collisional event in an low-mass inner asteroid belt are needed to explain the warm dust.

*Theme: Protoplanetary/Debris Disks*

## Schuyler Wolff

### Title: Excavating Archetypal Asteroid Belt Analogs

Abstract: Epsilon Eridani, Vega and Fomalhaut are among the nearest and most widely studied debris disks. These archetypal systems have robust fractional infrared luminosities with asteroid belt analog components (inferred from spectral energy distributions) and host complex circumstellar environments. Epsilon Eridani boasts at least one Jupiter-like exoplanet and several debris belts, Vega contains two debris belts and a tentative radial-velocity planet, and Fomalhaut hosts a eccentric Kuiper belt analogue. Through three legacy HST programs, we have achieved the deepest HST/STIS contrasts of the intermediate and outer disk regions to search for the influence of unseen planets and constraint dust properties. These sources are also the target of a MIRI GTO program to resolve the inner, asteroid belt analogues for these systems. Early JWST observations of Fomalhaut show a complex inner disk environment. Upcoming observations of Epsilon Eridani and Vega will begin to answer important questions about warm disk populations from planet interactions to dust transport mechanisms. We aim to determine if these asteroid belts are formed from evaporation of comets at the current ice-lines or if these are the remnants of fossil planetesimal belts.

*Theme: Protoplanetary/Debris Disks*

# Kadin Worthen

## Title: Modeling the Cloud Properties of VHS 1256b

Abstract: One of the biggest hurdles in understanding exoplanet and brown dwarf atmospheres is understanding their cloud properties (particle size, composition, etc). In substellar companions with ~1200<Teff <1700 K, silicates are predicted to be the dominant cloud species, however, the properties of these silicate clouds in substellar objects are not well constrained observationally. As a part of the high-contrast imaging community ERS program, VHS 1256b, a <20 MJ and T~1200K substellar companion orbiting an M-dwarf binary was recently observed with the MIRI MRS, leading to the detection of silicates in its atmosphere. We present constraints on the cloud properties in the atmosphere of VHS 1256b from modeling the silicate feature, in the region between 8-12 microns, seen in its MRS spectrum. Our model uses lab measured optical constants of silicate species and assumes Mie theory. We find that a model that includes a combination of amorphous olivine (MgxFeySiO4) and pyroxene (MgxFeySiO3) fits the data the best. The best fit model uses a Hansen distribution for silicate particle size, where grains with sub-micron radii are dominant. We rule out significant contribution to the 10-micron absorption feature from grains larger than a micron and we also rule out a log-normal particle size distribution. We constrain the ratio of the number of pyroxene particles to olivine particles in the atmosphere to be roughly 2:1. This result is the first constraint on the properties of silicate clouds in a substellar companion with JWST.

*Theme: Exoplanets/Brown Dwarfs*

# Virtual posters

## Natalie Allen

### Title: A novel framework for joint stellar photosphere/exoplanet atmospheric retrievals

Abstract: We are entering a golden age of exoplanet atmospheric characterization with the capabilities of JWST. With this new precision, it's only natural to push from the realm of giant planet atmospheric studies down to rocky planets. The small planets with potentially observable atmospheric signals will mainly be around small M-stars, which are known for being active and having significant spots/ faculae on their surfaces. These stellar inhomogeneities are able to impact the transmission spectrum obtained during transit and contaminate it. However, through this contamination, we are conversely able to obtain information on the state of the stellar surface. In this work, we present a fully Bayesian framework for the simultaneous retrieval of planetary atmospheres and a persistent, rotating stellar photospheric surface through an analysis of transmission spectra. If multiple planetary transits are observed in close proximity, then each acts as a “snapshot” of the state of the stellar disk at that point in time. This information can be stitched together to create a complete map of the stellar surface. As has already been seen in initial observations of planets in the TRAPPIST-1 system, the stellar contamination is not only significant, but seems to be evolving on a short timescale. Thus, we will also incorporate spot evolution into our framework to best match the available observations. This framework will be applicable to the medley of small planet observations planned with JWST, as understanding stellar contamination is crucial to finding terrestrial planet atmospheres outside of our solar system with JWST and beyond.

*Theme: Exoplanets/Brown Dwarfs*

# Sarah Betti

## Title: Characterizing Accretion and Formation Mechanisms across the Brown Dwarf and Planetary Mass Regimes

Abstract: Recent discoveries of accreting brown dwarfs (BD) and exoplanets have placed new importance on understanding the mechanisms that control their formation. Accretion mechanisms are well understood for stars, and substellar objects have been assumed to operate similarly; however, simulations suggest that accretion rates ($\dot{M}$) of substellar objects are controlled by their formation mechanisms. I will discuss my work disentangling physical and systematic effects in substellar accretion properties using the Comprehensive Archive of Substellar and Planetary Accretion Rates (CASPAR). CASPAR consists of >1000 measured $\dot{M}$s from ~800 T-Tauri stars, BDs, and planetary mass companions (PMC), making it the largest compiled sample of $\dot{M}$s for these objects to-date. I systematically rederive all physical and accretion properties using Gaia distances, consistent ages and evolutionary models, and a single set of line to total-accretion-luminosity scaling relations. This update decreases the M-$\dot{M}$ relation scatter by 7%, indicating that the remaining broad scatter is attributable to physical effects such as age and variability. I will also present results from a 2.5 year observing campaign using SOAR/TripleSpec4.1 to measure $\dot{M}$s for a sample of BDs and PMCs. NIR Paβ, Paγ, and Brγ line luminosities and ratios allow me to compare my observations to varying accretion models. As part of this survey, I detected the first NIR accretion signatures from a protoplanet, Delorme 1 (AB)b, and found it accretes at a rate of 3-4x10-8 MJ/yr. Ratios of its NIR emission lines are most consistent with planetary shock accretion models, and its high $\dot{M}$ suggests disk fragmentation formation.

*Theme: Exoplanets/Brown Dwarfs*

## Jordan Ealy

### Title: Title: Analysis of M Dwarf Flaring with the $\beta$ Pictoris Moving Group

Abstract: Representing ~70% of the stellar population, M dwarfs' relatively low temperatures and small radii generate prime conditions for planet detection and atmospheric characterization. The habitable zone is determined predominantly by the host star luminosity and do not often include the effects of stellar magnetic activity such as flaring. Flares result from the reorganization of the local magnetic field releasing panchromatic radiation including excess ultraviolet emission which has strong implications for observable phenomena such as atmospheric loss and induced photochemistry. Enhanced magnetic activity on M dwarfs compared to early main-sequence stars results in the energy released during flares becoming a non-negligible contributor to the overall radiation environment nearby. Thus, determining the evolution of flare properties is essential to interpret current and future observations of exoplanet hosts and their planets. With >100 M dwarf members, the beta Pictoris moving group presents an ideal launch point for the analysis of young (24 +/- 3 Myr), low mass star flaring rates within the context of broader flare studies. Using TESS observations, those with binaries or otherwise contaminated light curves were omitted leaving 50 viable low mass members. We identify and characterize flare properties of these stars such as total energy and cumulative flare rate. We present a preliminary analysis of these parameters and their insight into the co-evolution of stars and their planets using both models and observations. Work is ongoing to expand this analysis to other well-populated moving groups and therefore different ages to determine a relationship for flare evolution at early stages of planetary development.

*Theme: Astrobiology*

## Nicolas Godoy

### Title: GTO MIRI observations of 51 Eri b

Abstract: First observatory to offer coronagraphic capabilities in the mi-infrared, JWST-MIRI will open new avenues in the understanding of giant exoplanets atmospheric properties and formation mechanisms. By providing photometric measurements on the Rayleigh-Jeans tail of young giant planets, MIRI provides a powerful lever arm to precisely constrain their effective temperature and bolometric luminosity. The GTO 1241 program aims at characterizing the atmospheric properties with MIRI observations of four well-known sub-stellar companions. In particular, we will obtain this February MIRI images of one of the coolest exoplanet imaged thus far, 51 Eri b (~700K, ~9Mjup). Complemented with existing near-IR photometric measurements and spectra, our observations will provide unique constraints on the planet atmospheric properties, in particular by probing the ammonia absorption band at ~10.5µm expected for such low-temperatures planets in the presence of ammonia clouds. At a separation of 0.33", 51 Eri b is also our most challenging target: our observations will test the ultimate performance of JWST-MIRI at the shortest separations, as well as probing for planets down to 1Mjup at 1" and beyond assuming a hot start model. In this presentation we will present the first results from this program.

*Theme: Exoplanets/Brown Dwarfs*

## Samuel Grunblatt

### Title: TESS Giants Transiting Giants IV. An unlikely survivor: a low-density hot Neptune

Abstract: Hot Neptunes, gaseous planets smaller than Saturn with orbital periods less than 10 days, are rare. This is presumably due to strong stellar irradiation stripping planetary atmospheres over time through photoevaporation, often leaving behind only rocky planetary cores. We present the discovery of TIC 365102760 b, a 6.2 R$_\oplus$(0.55 R$_\mathrm{J}$), 19.2 M$_\oplus$(0.060 M$_\mathrm{J}$) planet transiting a red giant star every 4.21285 days. Though overlooked by broader transit searches, this planet was clearly detected in TESS full frame images by the focused TESS Giants Transiting Giants search, and confirmed with independent, ground-based radial velocity measurements. The large radius, high equilibrium temperature and low density of the planet suggest that without additional evolution, most or all of this planet's gaseous envelope should have been stripped after its formation. Its existence is suggestive of weak photoevaporation, late-stage orbital migration and/or planetary re-inflation. Further studies of this system with more precise photometry in additional bandpasses will be capable of better constraining mixing and mass loss rates for this planet's atmosphere.

*Theme: Exoplanets/Brown Dwarfs*

## Jacob Haqq-Misra

### Title: Could JWST Find Evidence of Extraterrestrial Technology?

Abstract: Atmospheric pollution is one consequence of global-scale technology on Earth. Some technology elevates existing levels of atmospheric constituents in the atmosphere, while other industrial processes can contribute novel pollutants that would not otherwise be present. The detection of such pollutants in the atmosphere of an exoplanet would be compelling evidence for the existence of extraterrestrial technology. In this talk, I discuss the search for spectroscopic "technosignatures" in exoplanetary systems, such as elevated levels of chlorofluorocarbons and other pollutants. I show that the era of JWST represents a pivotal transition in the ability for humanity to detect passive atmospheric technosignatures equal in strength to its own around the nearest stars.

*Themes: Exoplanets/Brown Dwarfs, Astrobiology*

## Hyerin Jang

### Title: Spatial distribution of crystalline silicates in protoplanetary disks: How to interpret JWST observations

Abstract: Crystalline silicate is an important tracer for the evolution of dust, the main building block of planet formation. In an inner protoplanetary disk, amorphous silicates are annealed by the high temperature and form crystalline silicates. These crystalline silicates are radially and vertically distributed by disk turbulence, radial drift, and radial diffusion. If we study the thermal annealing and dynamical mixing process of crystalline silicates, we can understand one of the main physics of the formation of terrestrial planets in the inner disk. In addition, the MIRI in the recently launched JWST observed the inner disk of PDS 70 in mid-infrared wavelength but only the upper layer due to the optically thick disk. From modeling spectral lines of crystalline silicates based on thermal annealing and dynamical processes, we can also study how those processes affect spectral lines in mid-infrared wavelength and how the MIRI observation represents the crystalline silicates in the midplane, where planets are mainly formed. From the comparison between radial and vertical mixing timescales, we conclude crystalline silicates in an observation well represent the midplane. In our modeled T-Tauri disk, different sizes of dust get crystallized in different ranges of the inner disk and distributed up to a few AU by the radial mixing process.

*Theme: Protoplanetary/Debris Disks*

## James Kirk

### Title: Tiberius: A JWST data reduction pipeline & applications to Cycle 1 data

Abstract: JWST provides an orders-of-magnitude increase in data compared to HST and ground-based observatories. Therefore, the community needs software capable of providing efficient, precise and accurate reduction of JWST data. To this end, I will present the newly open-source Tiberius software that is able to process JWST data from raw spectral images to exoplanet transmission spectra. Tiberius has been developed from a successful reduction package that has a legacy of analyzing ground-based observations. Tiberius is user-friendly Python code, with several students successfully using Tiberius to perform their first analyses of spectrophotometric data. I will present the Tiberius software and results from its analysis of real JWST data, including the first detection of CO2 in an exoplanet atmosphere, NIRSpec/PRISM and G395H spectra for the ERS program, and transmission spectra from additional GO programs. Given its early success, Tiberius is now ready to share as open-source Python code to aid in the community's analysis of JWST data.

*Theme: Exoplanets/Brown Dwarfs*

## Romain Mayer

### Title:

Abstract: Observation of exoplanets by direct imaging offers unique views on new worlds. Direct imaging allows us to receive emitted photons containing information on planet composition and atmosphere. One of the major difficulty of such observations lies in the presence of the star around which the planet orbits. Indeed, the radiation of the star contaminates the image that we observe. In order to detect potential exoplanets despite the contamination, we consider a statistical detection approach for direct images based on generalized likelihood ratio (GLR). We aim at building powerful and robust methods. We so developed methods using GLR, estimating the parameters (speckles, flux of the planet) for every pixels, summing on all the frames of the observation and using the correlation between a studied pixel and his neighbors. We propose 3 methods from the most general to the most simplified: indeed, the important calculation cost and the amount of data needed for the more general approach brings us to consider simplified ones. In order to know the theoretical optimal detection limit, we also build the Neyman Pearson test (the likelihood ratio test, that requires all parameters to be known). It allows us to compare, on simulated data, our three methods with the best detection and to choose between them. We also then compare the three algorithm on real data. We propose to apply this method to JWST NIRCAM and MIRI coronagraphic data from the ERS 1386 program. In this communication we will present first results of this study.

*Theme: Exoplanets/Brown Dwarfs*

## William Misener

### Title: Combusting Sub-Neptunes: coupled chemistry and atmospheric structure of hydrogen-silane-water atmospheres

Abstract: Sub-Neptune exoplanets are commonly hypothesized to consist of a silicate-rich magma ocean topped by a hydrogen-rich atmosphere. Substantial silicate vapor is expected to be in chemical equilibrium in the gas at temperature conditions typical of the magma-atmosphere interface of sub-Neptune planets, which can exceed 5000 K. Previous models of the atmospheric structure and evolution of these exoplanets have neglected this compositional coupling. We construct a coupled chemical equilibrium and atmospheric structure model, including silicate gas and its interactions with the background hydrogen. We find that silane and water are the main products of atmosphere-interior interactions in sub-Neptunes. These vapor products act as condensable species, decreasing in abundance with altitude. The resultant mean molecular weight gradient inhibits convection at temperatures above $\sim$2500 K, inducing a non-convective layer near the magma surface. The non-convective layer decreases the planet's radius compared to a planet with the same base temperature and a convective, pure H/He atmosphere. Therefore, we find that silicate vapor has major effects on the inferred envelope mass fraction and thermal evolution of sub-Neptune planets. This magma-atmosphere interaction could also impact the mass loss processes which can transform sub-Neptunes into super-Earths. Our results show that significant endogenous water can be produced by silicate-hydrogen chemistry without the need to accrete icy material, which could be important when considering the habitability of planets which accreted primordial hydrogen. The presence of silane vapor in the atmosphere may be observable with JWST, presenting a window into the interiors of these ubiquitous planets.

*Theme: Exoplanets/Brown Dwarfs*

## Catriona Murray

### Title: chromatic and chromatic_fitting: new open-source tools for atmospheric spectroscopy with JWST and beyond

Abstract: As we enter a new era of extremely precise exoplanet atmosphere spectroscopy, it is crucial that the tools we use for extracting planetary spectra are fast, flexible, and user-friendly. Here we present two new open-source Python packages for the community. CHROMATIC is a friendly program to read and write spectroscopic light-curves from/to a variety of formats, simplify many common calculations, and provide publication-ready visuals. CHROMATIC_FITTING, built on CHROMATIC, can perform efficient model fits to spectroscopic light-curve data and produce transmission (or emission) spectra. By combining any number of transit, eclipse, polynomial (in time, x/y, etc.), Gaussian Process, or user-defined models, we can simultaneously account for the spectral signatures imprinted by planets, stellar activity and instrumental systematics. CHROMATIC_FITTING also has the flexibility to carry out both 'white light' and multi-wavelength fitting, so can fully exploit the impressive wavelength coverage of facilities like JWST and spectrophotometric synergies between instruments. The aim of both tools is to easily and efficiently compare data reduction techniques, standardize the light-curve-fitting stage and understand the impact of model and parameter assumptions on transmission spectra. We hope these tools can help push the limit for extracting reliable exoplanet spectra and reduce uncertainties on atmospheric retrievals. As part of the ERS program, we successfully applied these tools to spectrophotometry from several of JWST's instruments. We demonstrate their unique versatility and future applicability to, not only, JWST, but other instruments both in space and on the ground.

*Theme: Exoplanets/Brown Dwarfs*

## Prasanta Kumar Nayak

### Title: Investigating variable accretion in T Tauri stars using FUV spectroscopy with UVIT

Abstract: T Tauri stars (TTS) are low-mass pre-main-sequence (PMS) stars, surrounded by protoplanetary disks. Accreting TTS are called Classical TTS (CTTS) and are characterized by strong line emission in UV (C IV, Si IV, He II) and optical (Hα). Non-accreting, disk-less weak-line TTS (WTTS) show weak emission lines due to chromospheric activity and lack H2 emission from disks. Variability in line luminosities is one of the defining characteristics of CTTSs. The main source of variability is thought to be the change in accretion rate. While optical spectroscopic and photometric surveys commonly search for variability, a few T Tauri stars have repeated observations in the UV. The evolution of the UV spectrum is moreover unknown, despite the importance of UV in heating the disk gas, influencing gas chemistry and driving photo evaporative winds. Recently, a monitoring program in UV spectroscopy has been initiated using the Hubble Space Telescope (HST), named Ultra-violet Legacy Library of Young Stars as Essential Standards (ULLYSES). Being members of ULLYSES program, we have developed a follow-up FUV spectroscopic observations using UVIT on AstroSat. 30 ks was allotted in the current observational cycle as a part of pilot study to observe a TTS (HD202917) and the observation is completed. We also obtained simultaneous ground-based optical spectra using CHIRON at the SMARTS telescope. I will present the results from this UVIT program and discuss how UVIT can be used to make a complementary program to the ULLYSES.

*Theme: Protoplanetary/Debris Disks*

## Kimberly Paragas

### Title: A Framework for Simultaneously Retrieving Atmosphere and Surface Properties of Hot, Rocky Exoplanets

Abstract: JWST's Mid InfraRed Instrument (MIRI) provides a unique opportunity to search for signatures of exoplanet surfaces with low resolution spectroscopy. Close-in, rocky planets orbiting M dwarfs are ideal targets for these studies. Though these planets are likely to have completely lost their primordial H/He atmospheres, they may outgas secondary, high mean molecular weight atmospheres. Consequently, it is important to consider how the presence of such an atmosphere with unknown mass and composition would impact our ability to robustly characterize the surfaces of rocky exoplanets. We modified the open-source Python package PLATON (Zhang et al. 2020) to perform simultaneous atmosphere and surface retrievals on secondary eclipse measurements of rocky super-Earth planets. These new features, including the ability to constrain different surface types through spectral features in emission and an improved prior scheme for retrieving an arbitrary mixture of atmospheric gases, will be made publicly available in a future release of PLATON. We demonstrate the capabilities of this framework on simulated secondary eclipse observations of the archetype super-Earth LHS 3844 b for scenarios in which the planet has (1) no atmosphere, (2) a thin atmosphere ($P_{surf} < 1$ bar), and (3) a thick atmosphere ($P_{surf} = 1$ bar).

*Theme: Exoplanets/Brown Dwarfs*

## Anitha Raj Rajkumar

### Title: A comprehensive homogeneous investigation of orbital ephemeris and transmission spectrum of WASP-19 b

Abstract: Exoplanets with ultra-short periods ($P < 1$ day) might experience orbital decay due to the tidal dissipation effect with the host star. My current work allows verification of the orbital ephemeris of the WASP-19b with the availability of long-term high-precision photometric and spectroscopic data including 20 unpublished transits from the Danish telescope. This place limits on the modified tidal quality factor Q'*. The same data allows for a detailed study of the atmospheric properties of WASP-19 b, via transmission photometry and spectroscopy. WASP-19 A is an active host star with its surface littered with starspots, which if not correctly modeled, systematics are introduced into the transit timing measurements and transit depth, which latter affects the exoplanetary transmission spectrum. Additionally the signal from stellar inhomogeneities can outweigh the signal from planetary spectral characteristics (Rackham, B., V., et al. 2022, arXiv, 220109905, submitted to RAS Techniques and Instruments as invited review.). Therefore, to perform a full and complete orbital ephemeris study of WASP-19b requires the modeling of detected starspots. Incidentally, failing to model both occulted and unocculted starspots can skew measurements in the planetary radius affecting the broadband transmission spectrum. Using the transit-starspot model, PRISM we perform the most complete, detailed, homogeneous analysis of all available data to estimate Q'* and study the atmospheric properties of WASP-19b with the help of ground- and space-based archival data.

*Theme: Exoplanets/Brown Dwarfs*

## Lakeisha Ramos-Rosado

### Title: The Hubble Space Telescope PanCET Program: An Extended Transmission Spectrum of the Warm Neptune HAT-P-26b

Abstract: We present a new and extended transmission spectrum of the warm Neptune HAT-P-26b obtained with the Hubble Space Telescope (HST) Space Telescope Imagining Spectrograph (STIS) G430L grating as part of the Panchromatic Comparative Exoplanet Treasury (PanCET) program. Our spectra cover a range of 0.3-0.5 microns, and we are combining it with previously published data from the 0.5-1.6 micron region taken with HST STIS G750L grating and HST Wide Field Camera 3 (WFC3), as well as with data at 3.6 and 4.5 microns from Spitzer Infrared Array Camera (IRAC). With our new wavelength coverage, we can better constrain the clouds in the atmosphere of the planet and similarly the metallicity. This work will be useful for future JWST observations, HAT-P-26b is a cycle 1 target and our results will provide a better characterization of the cloud deck level in the shorter wavelength range which will ease the modeling process for JWST. From (Wakeford et al. 2017) we know that HAT-P-26b has a lower bulk density compared to other Neptune-sized planets and it has a measured metallicity that is below what is expected from the mass-metallicity relationship observed in the Solar System giant planets. This planet is one of the few Neptune-mass planets to have a precise metallicity measured. This makes HAT-P-26b an important target because the atmospheric composition of close-in Neptune-sized planets opens a window to distinguish planet formation theories and evolution such as core-accretion, planetesimal accretion or other scenarios, these are unknowns regarding the formation of this class of planets.

*Theme: Exoplanets/Brown Dwarfs*

## Emily Rickman

### Title: Selecting benchmark brown dwarfs for JWST observations

Abstract: JWST has demonstrated an exceptional ability to obtain high-quality images and high-resolution spectra of giant exoplanets and brown dwarfs. But in order to utilize the power of direct imaging with valuable observing time, pre-selecting companion candidates is key, not only to assess the feasibility of direct detection but also to understand the fundamental physical and orbital parameters of directly imaged companions. Using long-period radial velocities, coupled with proper anomalies from Hipparcos and Gaia, provides a powerful tool to hunt for the most promising candidates for direct imaging. Not only does this increase the detection efficiency, but this wealth of information removes the degeneracy of unknown orbital parameters, like the inclination, leading to derived dynamical masses which can serve as benchmark objects to test models of formation and evolution. I present the detection of new directly imaged benchmark brown dwarfs from ground-based imaging with VLT/SPHERE with derived model-independent precise dynamical masses through combining relative astrometry, radial velocities, and astrometry from Hippacros-Gaia eDR3 accelerations. Thanks to extensive dynamical information on these objects, these brown dwarfs have exceptional precision on their model-independent masses, making them ideal targets for direct high-resolution spectroscopic follow-up with JWST. Probing these astrometric accelerators in the Solar neighborhood will ultimately lead us to a catalog of precisely characterized benchmark objects that can be used to test models of the formation and evolution of giant planets and brown dwarfs.

*Theme: Exoplanets/Brown Dwarfs*

## Daniel Thorngren

### Title: Using JWST Spectra to Explore Exoplanet Deep Interiors

Abstract: The giant planets of the solar systems have atmospheres depleted in metals compared to their bulk. These hidden metals are sequestered into cores and other compositional layers deep within the planet, but their presence is revealed through gravitational moments and bulk densities. The wide diversity of exoplanets would make this very valuable information to have for comparative planetology; for example, one could compare planets formed by gravitational instability vs core accretion, those in wide vs close-in (circularized) orbits, and dense vs puffy planets of the same mass. Whether metals are mixed into the envelope during formation depends on how and when they were accreted, such as pebble accretion or late planetesimal accretion. Using JWST atmospheric observations to set the upper boundary conditions on interior structure models, we can infer the quantity of metals in the deep interior to learn about planet formation on top of the existing approach focused on C:O ratios. I will describe how these models are constructed, show some early results of this approach, and discuss how these can inform our understanding of planet formation and evolution.

*Theme: Exoplanets/Brown Dwarfs*

## Marie Ygouf

### Title: Searching for Planets Orbiting Fomalhaut with JWST

Abstract: At a distance of only 7.7 pc, the bright (V=1.16 mag) A3V star, Fomalhaut (α PsA,HR 8728) was one of the original debris disk systems discovered by the IRAS satellite through the strong infrared excess at wavelengths longward of 12 µm. Fomalhaut has a complex planetary system, as reflected in its debris rings, the planetesimal collision that yielded Fomalhaut b, and the indications of unseen planets. Thus, it was with two goals in mind that Fomalhaut was made the target of an intensive Guaranteed Time program with the James Webb Space Telescope (PID#1193) employing both the NIRCam and MIRI instruments: 1) search for planets within the Fomalhaut system at 3-5 µm, including a definitive measurement of Fomalhaut b in the infrared; and 2) the complete characterization of the dust structures from 3-25 µm. In this communication we will report on the search for planets using NIRCam, our observing strategy, lessons learned, data processing and analysis in the context of MIRI data.

*Themes: Protoplanetary/Debris Disks, Exoplanets/Brown Dwarfs*

## Steven Young

### Title: Planetesimal Belts in Wide Binaries: a Kozai Origin for Transiting Exocomets?

Abstract: Planetary systems have been found to be a common occurrence across the galaxy and consist of both planets and/or belts of planetesimals. The orbits of planetesimals in these belts can be perturbed by the presence of nearby massive bodies such as a distant companion star and these companions, if sufficiently inclined and eccentric, can excite planetesimals to extremely high eccentricities: an effect known as the 'Eccentric Kozai Mechanism'. Due to these high eccentricities, the planetesimals can then pass very close to their host star, possibly producing observable transits. This scenario is one explanation for the deep, aperiodic dips in the light curves of some stars, such as Boyajian's star. This work quantifies, using a Monte Carlo model of the Kepler field, how often this mechanism would be expected to produce such a signature. It also tracks the spatial evolution and detectability of parent planetesimal belts under the influence of the 'Eccentric Kozai Mechanism' for comparison with future observations. These results help to constrain how important distant stellar companions are to the evolution and stability of planetary systems.

*Theme: Protoplanetary/Debris Disks*

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