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EXOPLANETS
PORTO
2026

CONFERENCE ABSTRACTS E-BOOK

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MONDAY, JUNE 29

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

PLANETARY SYSTEMS IN CONTEXT: DEMOGRAPHIC INSIGHTS FROM TESS

Michelle Kunimoto
University of British Columbia

The foundational processes that shape planetary systems – from violent migration to the long-term evolution of aging planets – are now being constrained by discoveries from NASA's Transiting Exoplanet Survey Satellite (TESS) mission. By delivering an all-sky census of planets orbiting bright, nearby stars, TESS has established a demographic foundation for testing theories of planet formation and evolution. In this talk, I will synthesize the emerging TESS-enabled demographic picture, highlighting key insights from early work on hot Jupiters and young planetary systems. I will then look ahead to the next phase of discovery as TESS's time baseline extends and analysis methods continue to mature. TESS is uniquely poised to map M dwarf planet populations, trace demographic trends with stellar age and environment, constrain the occurrence of rare but informative populations such as hot Neptunes – and may even offer new constraints on planets orbiting no stars at all.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

FORMING PLANETS AND THEIR MOONS: ESTABLISHING AN OBSERVATIONAL VIEW OF CIRCUMPLANETARY DISKS

Gabriele Cugno
University of Zurich

"Recent disk observations have revealed multiple indirect signatures of forming gas giant planets, yet high--contrast imaging has only rarely confirmed the presence of the suspected perturbers. A compelling explanation is that extinction from circumstellar material suppresses their near-infrared emission. However, a direct, empirical measurement of the extinction properties of protoplanetary disks has long remained out of reach.
In this talk, we present our analysis of the background star AS 209bkg, which shines through a wide annular gap in the disk of AS 209, where a protoplanet is suspected to be forming. We perform transmission spectrophotometry by combining new VLT/SPHERE and JWST/NIRCam observations with archival Hubble Space Telescope data from 2005. By modeling the spectral energy distribution of AS 209bkg over a 19-year baseline, we directly measure, for the first time, the extinction produced by disk gap material. We find that circumstellar disk extinction departs strongly from standard interstellar medium behavior, with important consequences for how we interpret high-contrast observations of planet-forming disks. Our results demonstrate that even wide, deep gaps can significantly attenuate the emission from embedded protoplanets, including those expected to be detectable under hot-start evolutionary scenarios. These measurements help reconcile the long-standing discrepancy between ALMA-inferred planet–disk interactions and the repeated non-detections in sensitive optical and near-infrared imaging campaigns.
This work is part of a broader effort in which we are applying the same transmission spectrophotometry technique to additional systems and newly acquired datasets, expanding the sample of lines of sight probing disk material at different ages, gap morphologies, and environments. Beyond measuring extinction laws, this growing dataset will allow us to directly constrain the dust properties within planet-hosting gaps and to measure the dust column density along the line of sight, providing an estimate of the dust mass present in these regions. Together, these measurements offer new empirical inputs for dust evolution models in protoplanetary disks and place quantitative constraints on the material that may obscure forming planets."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

SPINS AND ATMOSPHERE CHARACTERIZATION OF INFANT AND ADOLESCENT GIANT EXOPLANETS FROM KECK/KPIC HIGH-RESOLUTION SPECTROSCOPY

Chih-Chun Hsu &
Jason Wang; Jerry W. Xuan; Yapeng Zhang; Jean-Baptiste Ruffio; Dimitri Mawet; Luke Finnerty; Katelyn Horstman; Julianne Cronin; Yinzi Xin; Ben Sappey; Daniel Echeverri; Nemanja Jovanovic; Ashley Baker; Randy Bartos; Geoffrey Blake; Benjamin Calvin; Sylvain Cetre; Jacques-Robert Delorme; Greg Doppmann; Michael Fitzgerald; Quinn Konopacky; Joshua Liberman; Ronald Lopez; Evan Morris; Jacklyn Pezzato; Tobias Schofield; Andrew Skemer; J. Kent Wallace; Ji Wang

(2) Northwestern University, EVANSTON, IL, (3) UCLA, Los Angeles, CA; (4) Caltech, Pasadena, CA; (5) California Institute of Technology, Pasadena, CA; (6) University of Michigan, Ann Arbor, MI; (7) Northwestern University, Chicago, IL; (8) Leiden Observatory, Leiden; (9) University of California, San Diego, La Jolla, CA; (10) JPL, Pasadena, CA; (11) WMKO, Waimea, HI; (12) W. M. Keck Observatory, Waimea, HI; (13) W. M. Keck Observatory, Kamuela, HI; (14) University of California, Los Angeles, Los Angeles, CA; (15) University of California, San Diego, San Diego, CA; (16) University of Arizona, Tucson, AZ; (17) University of California, Santa Barbara, Northridge, CA; (18) UC Santa Cruz, Santa Cruz, CA; (19) University of California, Santa Cruz, Santa Cruz, CA; (20) Jet Propulsion Laboratory, Pasadena, CA; (21) Ohio State University, Columbus, OH

The majority of directly imaged exoplanets are young giant planets, overlapping brown dwarf companions at similar separations. Characterization of these imaged giant planets and substellar companions allows us to examine multiple formation channels and refine our theoretical understanding of planet formation. One of the long-sought observational efforts is to identify observables, such as orbital dynamics, spins, and chemical abundances, that separate these populations, which shed light on their formation pathways. In this talk, I present the largest high-resolution (R~35,000) spectroscopic survey to date of 32 directly imaged planets and brown dwarf companions using Keck/KPIC K-band high-resolution spectroscopy. Adding companions with spin measurements from the literature, we construct a curated spin sample of 43 benchmark companions and giant planets and 54 free-floating brown dwarfs and planetary-mass objects. We find the first clear evidence of distinct rotation speeds between imaged giant planets and brown dwarf companions at 4-4.5 σ assuming inclinations aligned with their orbits, while under randomly oriented inclinations the significance is at 1.6-2.1 σ. The higher fractional breakup velocities of planets can be interpreted as less angular momentum loss through circumplanetary disk braking during the planet formation phase. Our findings hold when considering various assumptions about planets. Notably, the mass ratio below 0.8% provides a clean distinction for rotation between giant planets and brown dwarf companions, indicating that both mass and mass ratios, which connect to the disk properties, are important to determine the terminal rotation of planets. Thus, we show that rotation is the most clear observable to disentangle the populations of imaged giant planets and brown dwarf companions, along with the well-known orbital eccentricities. Our novel analysis of specific angular momentum for 200+ isolated brown dwarfs and free-floating planetary objects with spin measurements indicates that their spins are also dependent on the disk environment. For atmospheric characterizations, I highlight our recent K-band abundance results on imaged planets and companions, including the first clear molecular detection of CO and H2O in the protoplanet PDS 70 b, which shows a C/O ratio similar to its host star and much lower than the high gas disk C/O ratio measured by ALMA. We also find a surprising non-detection of molecules on the protoplanet candidate AB Aur b under excellent observing conditions. This talk is concluded by highlighting our new H-band capability and the first KPIC H-band detection of a late-M companion, and connecting it to the new science enabled by the upcoming Keck/HISPEC, which will probe refractory species such as FeH in J and H bands for imaged giant planets at close separations, complementary to VLT/HiRISE and VLT/CRIRES+, and to what JWST/NIRSpec has offered to probe the refractory species such as H2S in longer wavelengths.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE GOLDEN AGE OF EXOPLANET ATMOSPHERES

Laura Kreidberg
Max Planck Institute for Astronomy

Exoplanet atmosphere characterization has entered a golden age, with many breakthrough results for planets of all sizes. In this talk, I will give a whirlwind tour of recent highlights. For gas giants, we are achieving unprecedented measurements of the 3D structure and atmospheric dynamics, including morning-evening limb asymmetries, dayside brightness temperature maps, and wind speed measurements. The chemical census is expanding, with recent measurements of isotopogues, refractory species, and cloud composition. The first spectra of cold, wide-separation Jovians have been measured, providing a direct comparison with our own Jupiter. Moving toward smaller planets, JWST has opened the door to the first detailed chemical inventory of their atmospheres, enabling direct inference of their interior structure and potential surface-atmosphere interactions. Finally, for rocky planets, searches for realistic secondary atmospheres and rocky surface features are now within reach. These advances herald a new era for exoplanet atmospheres and set the stage for transformative discoveries with Ariel and the next generation of ground-based telescopes.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

MAPPING THE LATE STAGES OF GIANT PLANET EVOLUTION WITH JWST IMAGING OF BENCHMARK COLD PLANETS EPS IND AB AND EPS ERI B

Aniket Sanghi &
Jerry Xuan, Jorge Llop-Sayson , Jean-Baptiste Ruffio, Yapeng Zhang , Dimitri Mawet, Jason Wang, William Thompson, Heather Knutson, Rebecca Oppenheimer, Christian Marois, Alexander Madurowicz, Katelyn Horstman, Bjorn Benneke, Charles Beichman, Jarron Leisenring), Marie Ygouf, Andras Gaspar, James Mang, Caroline Morley

Caltech, UCLA, UCSD, Northwestern University, NRC Herzberg, AMNH, Dominion Astrophysical Observatory, STScI, NASA JPL, University of Arizona, UT Austin

Directly measuring an imaged planet's mass is one of the most powerful tools available to study their formation and atmospheres. When combined with luminosity and age constraints, such objects can serve as benchmarks that calibrate substellar evolutionary models and test their underlying assumptions about planet formation channels, atmospheres, and internal physics. With its unparalleled sensitivity, JWST is expanding this benchmark sample, for the first time, to colder and older planets more similar in age and temperature to the Solar System gas giants. As the two closest confirmed extrasolar giant planets to Earth (at ~3.5 pc), Eps Ind Ab and Eps Eri b, are the most favorable targets for detailed comparative planetology studies with Jupiter and Saturn using JWST imaging and spectroscopy.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

DISCOVERY OF A THIRD JOVIAN PLANET AROUND BETA PICTORIS WITH JWST/NIRSPEC

Aidan Gibbs &
Jean-Baptiste Ruffio; Quinn Konopacky; Aneesh Baburaj; Travis Barman; Alexis Bidot; Beck Dacus; Clarissa Do Ó; Bruce Macintosh; Alex Madurowicz; Marshall Perrin; Jerry Xuan

University of California, San Diego; Northwestern University; University of Arizona; STScI; University of California, San Diego; Caltech; University of California, Santa Cruz; STScI; STScI; University of California, Los Angeles

Beta Pictoris is an emblematic system for understanding planetary system evolution at an early age, hosting two known massive planets interacting with a rich and dynamically complex debris disk only ~20 Myr after formation. Here we report the discovery of a third planet orbiting beyond ~20 au with a mass below ~2 Jupiter masses, detected using JWST/NIRSpec IFU high-resolution spectroscopy (R~2,700). The planet is strongly detected in G395H beyond > 4 microns, with CO features clearly visible, but not in similar NIRSpec data at shorter wavelengths, implying an effective temperature below ~600 K. The lack of detection between 3-4 microns may plausibly be due to strong CH4 absorption. These same observations also measure the volatile-to-refractory abundance ratio in Beta Pic b, providing constraints on the relative accretion of solids and gases during formation. These results demonstrate the power of space-based high-resolution spectroscopy not only for characterizing exoplanet atmospheres and formation pathways, but also for discovering new planets that can be obscured by exozodiacal dust in classical photometric high-contrast imaging.

EXTREME – BUT NOT EXTREME ENOUGH? THE RECORD-STRETCHING ORBIT OF A HIDDEN "FAILED HOT JUPITER"

Alexander Venner &
George Zhou
Max Planck Institute for Astronomy, University of Southern Queensland

"Hot Jupiters are among the most iconic exoplanets known, yet their origins and formation remain shrouded in mystery. One popular hypothesis for Hot Jupiter formation is high-eccentricity migration, where a giant planet forms at a wide orbit but is subsequently dynamically excited to an extreme orbital eccentricity, and then brought to a low-eccentricity short-period orbit via tide-driven orbital circularisation. This hypothesis entails the existence of transient Hot Jupiter progenitors with extremely high orbital eccentricity orbits; however, such high eccentricities are extremely rare among present-day giant exoplanets, with only five confirmed with eccentricities above >0.9 to date.

Here we present a new investigation of HD 28254 Ab, a neglected RV-discovered giant exoplanet recently proposed to have an eccentricity much higher than originally thought. Unfortunately, the critical periastron passage has not been captured in existing RVs, so new observations were necessary to uniquely resolve its orbital eccentricity. We therefore intensively followed its 2025 periastron passage with the MINERVA-Australis spectrograph array to definitively determine whether HD 28254 Ab could be a Hot Jupiter progenitor. Our observations captured the extremely rapid swing in the stellar radial velocity during the planet's close approach for the first time, uniquely resolving its orbital eccentricity.

We find that HD 28254 Ab is likely to be the most eccentric exoplanet known, careening between separation extremes around 0.1 AU and 4.8 AU in the course of its 3.6-year orbit. We argue that its orbit is likely to have been excited by the past influence of a known wide stellar companion. However, unlike several other extreme-eccentricity giant exoplanets, the orbital separation at periastron remains too large for tidal circularisation to take effect within the main sequence lifetime of the primary star. We therefore propose that HD 28254 Ab is marooned on its high-eccentricity orbit and can be reckoned as a "failed Hot Jupiter", stuck on a steady-state orbit and unable to achieve the short-period orbit of a Hot Jupiter. The properties of the known sample of extreme-eccentricity giant planets suggests that similar "failures" may be as common as bona-fide Hot Jupiter progenitors, highlighting an underappreciated challenge for the high-eccentricity migration hypothesis."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

JWST MIRI TIME-SERIES AS A SERENDIPITOUS DIRECT IMAGING SURVEY: WIDE-ORBIT PLANET SEARCHES FOR ROCKY PLANET HOSTS

Yifan Zhou &
Yihan Li, Rachel Bowens-Rubin, Mary Anne Limbach, Hannah Diamond-Lowe, Kevin B. Stevenson, Andrew Vanderburg, Giovanni Strampelli, and Gregory J. Herczeg

University of Virginia, Yihan Li – Department of Astronomy, Peking University Rachel Bowens-Rubin – Department of Astronomy, University of Michigan / Eureka Scientific Inc. Mary Anne Limbach – Department of Astronomy, University of Michigan Hannah Diamond-Lowe – Space Telescope Science Institute Kevin B. Stevenson – Johns Hopkins APL Andrew Vanderburg – Harvard & Smithsonian Giovanni Strampelli – Space Telescope Science Institute Gregory J. Herczeg – Kavli Institute for Astronomy and Astrophysics, Peking University Cassidy Walker – Michigan State University

MIRI/F1500W time-series observations and the Rocky Worlds JWST DDT program targeting rocky planet eclipses provide deep 15 μm imaging as a byproduct. We demonstrate the dual-purpose utility of these datasets through reference star differential imaging analysis of ten M-dwarf systems totaling 200 hours, including TRAPPIST-1. Our PSF subtraction achieves median 5σ contrasts of 1.5×10^{-3} at 1″ and 2.1×10^{-4} beyond 3″—sufficient to detect 2-4 MJup planets at 10-50 AU in 1-5 Gyr systems. This initial application to ten rocky planet hosts provides the first systematic demonstration of the high-contrast imaging sensitivity of F1500W time-series images for detecting wide-orbit companions. The established method is ready to apply to larger sample sizes, enabling enhanced statistics on occurrence correlations between inner rocky planets and outer gas giant planets around M-dwarfs—a parameter space that remains poorly constrained compared to solar-type stars. We identify 25 background sources within 50″ of planet hosts. For several planet host stars, background sources will approach within 1-2″ by 2030-2035 due to proper motion of the targets, which will require careful PSF modeling in future observations. This work demonstrates how atmospheric characterization programs naturally generate complementary high-contrast imaging probes without dedicated telescope time, offering a novel way to detect gas giant planets and enhance holistic understanding of M-dwarf planetary systems.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

A MULTI-WAVELENGTH VIEW OF PLANETARY DEBRIS AND ACCRETION ONTO WHITE DWARFS: THE CORNERSTONE SYSTEM G29-38

Tim Cunningham
Harvard & Smithsonian | Center for Astrophysics

White dwarfs, the remnants of most stars, often show atmospheric metal pollution from disrupted planetary systems, providing a unique window into exoplanetary composition and dynamics. Frequently accompanied by dusty debris disks, these systems provide a unique laboratory for real-time studies of planetary disruption and accretion. I will present an extensive multi-wavelength monitoring campaign of the benchmark system G29-38 that, for the first time, jointly constrains its accretion flow and debris-disk evolution. Time-resolved JWST NIRSpec and MIRI spectroscopy resolve the detailed mineralogy of the dusty disk, reveal cool dust components that constrain its outer extent, and deliver the first sensitive probe of sub-minute mid-infrared variability, tracing rapid thermal changes in the disk. Complementary multi-epoch HST/COS spectroscopy tracks year-scale variations in photospheric metal abundances, yielding direct, time-dependent measurements of the accretion rate and composition of the infalling material. We compare these constraints to ongoing multi-epoch Chandra X-ray observations, which provide the first probe of accretion-rate variability onto a metal-polluted white dwarf. Together, these observations deliver the first integrated, time-domain view of a planetary debris disk and its ongoing accretion onto a white dwarf, establishing G29-38 as a cornerstone system for understanding the fate of planetary systems.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE ORIGINS OF EXOCOMETS IN BETA PICTORIS

Klaudia Jaworska &
Jens Hoeijmakes; Klaudia Jaworska; Bibiana Prinoth; Sofia Back
Lund University; ESO Garching; Lund University

Long before the discovery of the first exoplanets, exocomets were identified in the young Beta Pictoris system in the late 1980's. These are transiting, evaporating planetesimals that can be seen using high resolution spectroscopy, as they catastrophically evaporate during close passes by the hot A-type host star due to their highly elliptical orbits. Although exocomets have been observed in Beta Pictoris on thousands of occasions, their dynamical origins and compositions remain poorly understood, and there are only a few other systems where exocomets have been confidently identified. Nevertheless, exocomets are hypothetically extremely interesting, as the compositions of the evaporated material can be measured in detail, and this material likely participated in the system's planet formation process only 20 Myr ago. In this talk, I will discuss our recent studies of the HARPS archive to search for new observational exocomet phenomenology as well as N-body simulations that elucidate the dynamical evolution of planetesimals in the beta Pictoris system. These simulations indicate that there should exist two channels by which planetesimals evolve onto star-grazing orbits, and that the observable dynamical properties depend strongly on details of the gravitational dynamics shaped by the two gas giants in the system.

SPECTROSCOPIC CONFIRMATION OF A SECOND EMBEDDED PLANET IN THE WISPIT 2 SYSTEM

Chloe Lawlor &

Chloe Lawlor(1), Richelle van Capelleveen(2), Guillaume Bourdarot(3), Christian Ginski(1), Matthew Kenworthy(2), Tomas Stolker(2), Laird Close(4)

1. School of Natural Sciences, Center for Astronomy, University of Galway, Galway, H91 CF50, Ireland 2. Leiden Observatory, Leiden University, Postbus 9513, 2300 RA Leiden, The Netherlands 3. Max Planck Institute for Extraterrestrial Physics, Gießenbachstraße 1, 85748 Garching, Germany 4. Center for Astronomical Adaptive Optics, Department of Astronomy, University of Arizona, 933 N. Cherry Avenue, Tucson, AZ 85718,13 USA

"The striking multi-ringed circumstellar disk of WISPIT 2 has recently been confirmed to host a young gas giant embedded in its disk. As the detection of embedded planets in disks is incredibly rare, this system has become of high interest to the scientific community. While still young (~5.1 Myrs) this system offers a unique opportunity to study the earliest stages of giant planet formation.

We present new interferometric observations obtained with VLTI/GRAVITY in the K-band that confirm the existence of a second embedded planet, WISPIT 2c. The extracted K-band spectrum of this companion exhibits a CO band-head at 2.3 microns and a continuum shape, characteristic of a young, self luminous giant planet. Comparison of the observed spectrum with atmospheric grid models constrains the physical properties of WISPIT 2c, giving an effective temperature in the range 1700-2400 K, a radius of 1-1.8 R_J and a mass range of 7-12 M_J, within expected ranges of a newly formed gas giant.

WISPIT 2c sits just beyond the inner-most ring of the disk at roughly 14 au from the host star, and is approximately twice as massive as the previously detected WISPIT 2b. The system now becomes a close analogue to PDS 70, with planets in both systems are at broadly similar separations and have comparable masses. The similarities between these may imply the existence of a ""Goldilocks zone"" where conditions in the disk may favour rapid growth and early giant planet formation. Together, WISPIT 2 and PDS 70 broaden our understanding of planetary architectures at the earliest stages of planet formation and provide key constraints on models of planet-disk interactions."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

UNVEILING THE DIVERSE ARCHITECTURES AND EVOLUTIONARY PATHWAYS OF NEPTUNE-SIZED PLANETS: RESULTS FROM GAPS AND HONEI

Luigi Mancini &
Luca Naponiello
University of Rome "Tor Vergata"

"Neptune-sized exoplanets serve as a critical bridge between terrestrial worlds and gas giants, yet they exhibit a remarkable diversity in composition and evolutionary history. This abstract synthesizes recent discoveries from the Global Architecture of Planetary Systems (GAPS) and Hot Neptune Initiative (HONEI) programs, focusing on targets that challenge conventional theories of planetary formation. A primary highlight is TOI-1853 b, a super-massive Neptune-sized planet with a mass of a bulk density of 9.7 g/cm3. This density, roughly six times that of Neptune, suggests an interior dominated by heavy elements and a formation history likely shaped by high-speed proto-planet collisions or high-eccentricity migration.

In contrast, we characterize the young (~700 Myr) mini-Neptune TOI-1430 b, which possesses a low density and a confirmed evaporating helium atmosphere. Evolutionary models predict that TOI-1430 b will completely lose its H/He envelope within 200 Myr, crossing the radius gap to become an envelope-stripped rocky super-Earth. Further diversity is evidenced by BD+00 444 b, a sub-Neptune on an eccentric orbit (e≈0.3), and its potential companion BD+00 444 c, which is located within the habitable zone. Within the HONEI framework, we also report TOI-5800 b, the most eccentric planet (e~0.3) ever discovered with an orbital period under three days, and TOI-5795 b, a hot super-Neptune orbiting a metal-poor star ([Fe/H]=−0.27±0.07). Many of these targets, particularly BD+00 444 b and TOI-5800 b, exhibit exceptionally high TSM, marking them as priority candidates for the JWST and Ariel. These systems provide unique testbeds for investigating the roles of photo-evaporation, tidal migration, and volatile delivery in shaping the architectures of Neptune-sized worlds."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

WASP-12B: DIAMOND IN THE ROUGH, OR JUST MISUNDERSTOOD?

Taylor Bell
ESA/AURA; STScI

A planet's carbon-to-oxygen ratio (C/O) is often treated as a chemical fingerprint of giant-planet formation. For hot Jupiters, however, our baseline expectation is that atmospheres should be oxygen-rich; most protoplanetary disks inherit sub-unity C/O from their host stars, and core-accretion growth naturally mixes oxygen-bearing solids into the envelope. Early claims that WASP-12b has C/O >= 1 positioned it as the canonical ""carbon-rich"" hot Jupiter, implying depleted H2O and enhanced carbon chemistry and fueling a broader ""diamond planet"" narrative. With JWST spectra now suggesting several ultra-hot Jupiters may have atmospheres consistent with near-unity C/O, WASP-12b's long-standing role as the carbon-rich hot Jupiter deserves a careful re-examination.

I re-examine the observations used to infer high C/O in WASP-12b and explore how those inferences can be reshaped by ultra-hot atmospheric physics and the planet's extended environment. At WASP-12b's dayside temperature, H2 and H2O can thermally dissociate (and partially ionize), increasing continuum opacity (via H-) and muting near-IR water features even if the bulk composition is not carbon-rich. I also assess how atmospheric escape can bias the very measurements that anchored the original high-C/O inference. In particular, Bell et al. (2019) proposed a CO-rich mass-loss scenario to explain their Spitzer phase curves, and additional 4.5 um emission from the escaping gas stream could bias transit-only or eclipse-only interpretations and, in turn, push earlier retrievals toward CO-rich, water-poor solutions.

I conclude with a synthesis of new observations and targeted re-analyses of archival datasets using retrievals that account for dissociation/ionization physics and wavelength-dependent contamination. The goal is to place WASP-12b in the JWST-era context for ultra-hot Jupiter chemistry, clarifying what its spectrum can (and cannot) tell us about elemental ratios and interior composition under extreme irradiation.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

SYNTHESIZING ACCRETION AND CIRCUMPLANETARY DISK PROPERTIES OF A WIDE ORBIT PLANET WITH HST AND JWST

Claire Finley &
Brendan Bowler, Ya-Lin Wu
University of California, Santa Barbara; National Taiwan Normal University

Many details of giant planet formation and evolution remain untested due to limited observational constraints on when they assemble and grow through gas accretion. Two key diagnostics—ultraviolet (UV) accretion signatures and mid-infrared (IR) circumplanetary disk excess—offer critical insight into this process, but are rarely accessible for the same system due to practical observing challenges. I will present new UV and mid-IR direct imaging of the wide planetary-mass companion SR 12 c with HST/WFC3-UVIS and JWST/MIRI. These data expand SR 12 c's spectral energy distribution (SED) to span 0.2–21 microns, making it one of the most complete SEDs of a young imaged giant planet to date. UV photometry shows a strong Balmer continuum excess, and hydrogen slab models yield an accretion luminosity and mass accretion rate. Combined with previous measurements, we explore accretion variability across a range of timescales spanning months to years. In the mid-IR, substantial thermal excess from a circumplanetary disk is evident, and the MIRI photometry directly constrains the disk structure, temperature, and extent of grain growth. This multi-wavelength snapshot of SR 12 c adds to the growing sample of distant planets with detailed accretion and disk constraints, helping to establish the timescales and physical processes that govern giant planet formation.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

MAPPING THE ATMOSPHERE OF TOI-561 B: FIRST JWST/NIRSPEC PHASE CURVE OF ULTRA-SHORT PERIOD PLANET WITH A THICK ATMOSPHERE

Lisa Dang &
Samuel Boucher, Alex McGinty, Nicole L. Wallack, Johanna K. Teske, Anjali Piette, Tim Lichtenberg, Mykhaylo Plotnykov, Bo Peng, Emma Postolec, Mark Hammond, Raymond Pierrehumbert, Diana Valencia

University of Waterloo, Université de Montréal, University of Oxford, Carnegie Institution for Science, Carnegie Institution for Science, University of Birmingham, University of Groningen, University of Toronto, Stanford University & University of Toronto, University of Groningen, University of Oxford, University of Oxford, University of Toronto

Ultra-short period rocky planets are expected to be stripped of gaseous envelopes due to intense stellar irradiation. Surprisingly, recent eclipse observations of TOI-561 b revealed a ~3-5 μm emission spectrum best explained by a thick volatile secondary atmosphere, thereby challenging our understanding of atmospheric outgassing and retention on lava planets. TOI-561 b stands out as the lowest-density lava world known, with a density analogous to the iconic 55 Cnc e, making it a unique laboratory for studying volatile retention under extreme conditions. However, the low dayside emission observed in eclipse-only data is degenerate: it could be explained by either high albedo or efficient heat recirculation to the nightside. To break this degeneracy and characterize this unexpected atmosphere, we present the first phase curve observations of a low-density lava world: multi-orbit JWST/NIRSpec G395H spectroscopic phase curve observations of TOI-561 b. Our phase curve maps the planet's thermal emission as a function of longitude, directly constraining the heat recirculation efficiency and Bond albedo. This thorough analysis confirms the high albedo inferred from previous eclipse-only results while also quantifying the planet's energy redistribution. Our observations have important implications for understanding atmosphere-interior interactions on rocky worlds in extreme environments and, more importantly, reinforce that volatile outgassing could play an important role in the presence of atmospheres on terrestrial worlds.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

A CLEAR VIEW OF STAR–PLANET INTERACTIONS IN THREE ULTRA-HOT JUPITER SYSTEMS USING JWST

Stephen Schmidt &
David Sing, Erin May, Joshua Lothringer, Kevin Schlaufman
Johns Hopkins University, Johns Hopkins Applied Physics Laboratory, Space Telescope Science Institute, Johns Hopkins University

Ultra-hot Jupiters (UHJs) provide the best opportunities to constrain the physical processes like intense instellation, magnetic fields, atmospheric circulation, and tides that mediate star–planet interactions. We comprehensively study the three UHJ systems KELT-7, WASP-76, and WASP-12 with panchromatic space-based data from both the Hubble and James Webb Space Telescopes that are part of the JWST Grand Tour Cycle 3 treasury program. For the KELT-7 system, we use new techniques to overcome partial detector saturation in JWST/NIRISS to construct a full 0.2–5.3 micron transmission spectrum. Our retrievals indicate a metal-rich atmosphere and, in contrast to previous work, no support for H- opacity. In addition, we find evidence for an inhomogeneous stellar surface that is unexpected for a star of KELT-7's mass and evolutionary state. We propose the best explanation for our observation is strong magnetically-mediated star–planet interactions in the plausibly triply synchronized KELT-7 system. For the WASP-76 system, we observe with JWST/NIRISS SOSS a feature-rich 0.85–2.85 micron transmission spectrum with planet limb–limb asymmetries that may imply differences in morning/evening corundum cloud coverage. We contextualize these results with ground-based high-resolution results showing nightside iron condensation using predictions from UHJ atmospheric circulation models. For the WASP-12 system, we use our JWST/NIRSpec PRISM 0.5–5.5 micron transmission spectrum to both infer the metallicity and elemental abundance ratios of WASP-12 b as well as the mean density of its host star. We use the latter data to conclusively resolve the evolutionary state of WASP-12. We also present an updated stellar tidal quality factor inference that accounts for obliquity damping in the WASP-12 system given its misaligned orbit. We find Qstar ~ 10^6, an order of magnitude higher (i.e., less dissipative) than previously thought and much more in line with both population-level Qstar inferences and theoretical models of star–planet tidal interactions. Our results demonstrate the importance of panchromatic data for the interpretation of exoplanet atmospheres. We suggest that magnetically-mediated star–planet interactions may be especially strong in triply synchronized systems and that stellar tidal quality factor inferences must consider obliquity damping to obtain accurate results.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

IMAGING YOUNG, TEMPERATE SUB-JUPITERS: EARLY RESULTS FROM JWST DIRECT IMAGING EXOPLANET SEARCHES

Beth Biller &
SURVEY 6005/GO 4050/GO 5835 team including: Aarynn Carter; Rodrigo Ferrer-Chavez ; Rohan Kane (STScI); Ell Bogat (University of Maryland); Giovanni Strampelli (STScI), Julien Girard (STScI); Kellen Lawson (NASA Goddard); Jason Wang (Northwestern University); Mark Booth (UK ATC); Johanna Vos (Trinity College Dublin); Yifan Zhou (University of Virginia); Katie Crotts (STScI); Evelyn Bruinsma (STScI); Skyler Palatnick (UCSB); Kellen Lawson (GSFC); Isa Rebollido (ESAC); Yiting Li (Michigan); Sebastian Marino (Exeter); Ben Sutlieff (Edinburgh); Aniket Sanghi (Caltech); Raphael Bendahan-West (Exeter); Clemence Fontanive (Edinburgh); Klaus Stephenson (Victoria)

University of Edinburgh, STScI; Northwestern University; STScI; University of Maryland; STScI, STScI, NASA Goddard, Northwestern University; (UK ATC); (Trinity College Dublin); (University of Virginia); (STScI); (STScI); (UCSB); (GSFC); (ESAC); (Michigan);(Exeter); (Edinburgh); (Caltech); (Exeter); (Edinburgh); (Victoria)

The extreme IR sensitivity of JWST enables imaging of sub-Jupiter exoplanets for the first time, yielding sensitivity even to young analogues of Saturn. The first survey to systematically search for wide sub-Jupiter exoplanets around young moving group stars is now underway, with NIRCam 2.0+4.4 micron coronagraphic imaging of 170 stars in JWST Cycle 2 and Cycle 3 (GO 4050, GO 5835, SURVEY 6005). First epoch observations are complete, with ~2000 individual sources detected, most of which are background interlopers. We have proposed follow-up observations to confirm common proper motion for ~tens of exoplanet candidates with 2.0 micron – 4.4 micron colors indicative of red, exoplanet-like colors. Observations of all survey targets reach sensitivities sufficient to image sub-Jupiter exoplanets, with more than half of the sample reaching the sensitivity sufficient to image to 0.5 MJup planets and 1/3 of the sample yielding sensitivity down to young Saturn analogues. Thus this survey has the potential to discover the coldest and lowest mass exoplanet directly imaged to date (Teff ~ 250-400 K, similar to that of habitable zone exoplanets). This ongoing JWST survey for sub-Jupiter planets will help pave the way towards eventual ELT high-contrast observations of solar-system age giant planets in reflected light, via 1) developing the techniques for reference star PSF subtraction necessary for high-contrast imaging, 2) improving our understanding of wide giant planet demographics, and 3) imaging and characterizing atmospheres with temperatures similar to solar system age giant planets in the habitable zones of their stars. These surveys have also yielded ~10 debris disk detections, including the first imaging detection of a number of disks around M star primaries with infrared excesses, as well as further confirmation of exoplanet-like colors for the ~1 Saturn mass exoplanet candidate TWA-7b.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

IS THERE AN ATMOSPHERE ON HOT ROCK LHS 1478 B?

Prune August &
Lars A Buchhave, Alexander Rathcke, Hannah Diamond-Lowe
Technical University of Denmark, DTU Space, STScI

The prospects for Venus-like CO_2 atmospheres around hot Earth-sized planets orbiting M dwarfs (Teq = 300K – 1,500K) are looking increasingly dire. Recent JWST observations, including the Hot Rocks Survey (GO 3730, PI Diamond-Lowe) and the DDT Rocky Worlds programme, have used MIRI at 15 microns to search for atmospheric signatures through dayside thermal emission, with most targets showing eclipse depths inconsistent with substantial CO_2 atmospheres.
LHS 1478 b (Teq = 595K, Rp = 1.23 R⊕, Mp = 2.33 M⊕) stands out as a potentially critical exception. Initial Hot Rocks Survey observations revealed a shallow 15-micron eclipse, suggesting CO2 absorption or high albedo — making it perhaps the most promising atmospheric candidate identified to date in this regime. However, strong correlated noise limited the original eclipse detection to <3σ significance, leaving the result ambiguous.
A seven-eclipse follow-up campaign (JWST GO 7675, PI August) is underway, with preliminary data already robustly confirming the eclipse signal. I will present early results from the first three observations (two MIRI/LRS, one Imaging at 15 microns) and discuss implications for atmospheric survival around M dwarfs in this temperature regime.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

A HIGH REFRACTORY-TO-VOLATILE RATIO FOR THE ULTRA-HOT JUPITER WASP-121 B FROM A PANCHROMATIC JWST DAYSIDE SPECTRUM

Kim Angelique Kahle &
Paul Mollière (1), Laura Kreidberg (1), Nicholas Storm (1), Lorena Acuña (1), Cyril Gapp (1), Bertram Bitsch (2), Thomas M. Evans-Soma (1,3), Thomas Henning (1)

(1) Max Planck Institute for Astronomy, (2) University College Cork, (3) University of Newcastle

“The daysides of ultra-hot Jupiters provide a window into the chemical inventory and formation pathways of giant planets: the extreme temperatures in their photospheres inhibit the condensation of refractory elements into clouds, placing both volatile (e.g., CO) and refractory (e.g., SiO) species in the observable gas phase. Simultaneous observational constraints on these inventories are crucial, as the planetary refractory-to-volatile ratio can break degeneracies in planet-formation and evolution models that are left unresolved by measurements of the carbon-to-oxygen ratio.
We present the first panchromatic (0.6-12 micron) dayside emission spectrum of the benchmark ultra-hot Jupiter WASP-121 b. Our joint atmospheric retrieval analysis of all JWST datasets provides the most accurate constraints to date on the inverted dayside temperature profile and robustly detects volatile and refractory species. In particular, we detect a strong SiO vibrational bandhead at mid-infrared wavelengths, providing new insights into the silicate inventory of ultra-hot Jupiter atmospheres. Our analysis reveals a statistically significant enhancement of the planetary refractory-to-volatile ratio from the host star value, which remained hidden in previous single-instrument studies. This finding suggests a rock-rich formation scenario in which planetesimals or small dust grains could have played a major role in enriching the planet’s atmosphere. This result provides a new window into WASP-121 b’s origins and highlights the transformative potential of combined JWST spectra for determining the structure, chemistry, and formation of highly irradiated planets.”

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

ATMOSPHERIC PROPERTIES OF PLANETARY MASS COMPANIONS ACROSS L, T AND Y TYPES: A UNIFORM JWST-MIRI ANALYSIS.

Maël Voyer &
Quentin Changeat, Pierre-Olivier Lagage and the EXOMIRI TEAM
CEA / Paris University, Groningen University, CEA.

The increasing number of directly imaged planetary-mass companions observed with the James Webb Space Telescope (JWST) provides a unique opportunity to study substellar atmospheres over a wide range of temperatures, and chemical regimes. In this talk, we present a uniform reduction and analysis of a sample of planetary-mass companions spanning the L, T, and Y spectral classes, all observed with the JWST MIRI Low-Resolution Spectrograph (MIRI-LRS). The targets are selected to have comparable masses, of order ~10 Jupiter mass but different effective temperatures, enabling a comparative study of the evolution history of these objects. We develop a consistent data-reduction strategy to uniformly handle all the targets, which is necessary for a robust comparison and to minimize the systematics introduced by heterogeneous pipeline choices. Using a common atmospheric retrieval framework, we extract atmospheric properties (molecular abundances, thermal structures, and cloud properties) across the sample.By adopting a population-level approach, this study aims to place individual objects in a broader atmospheric context and to identify commonalities and divergences across the L–T–Y sequence. The results we present provide new constraints on substellar atmospheric physics and offer valuable benchmarks for evolutionary and atmospheric models, as well as a reference for future comparative studies with JWST and upcoming facilities.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

SEARCHING FOR FRIGID WORLDS AROUND WHITE DWARFS WITH JWST

Sydney Jenkins &
Andrew Vanderburg, Mary Anne Limbach
Massachusetts Institute of Technology, Harvard University, University of Michigan

Though planets are common around main-sequence stars, very little is known about how stellar evolution sculpts the planet population. JWST's direct imaging capabilities provide a powerful new tool to probe the demographics of evolved systems by searching for planets around white dwarf stars. Two programs leading this effort are the MIRI Exoplanets Orbiting White dwarfs (MEOW) survey and its companion program, the Planet Authentication in White-dwarf Systems (PAWS) survey. MEOW has mapped 16 nearby white dwarf systems with a combination of direct imaging and the thermal excess technique, identifying dozens of planet candidates. Follow-up observations with PAWS will definitively differentiate between true planets and spurious background sources using high-precision proper motion measurements. Though the PAWS program is still underway, with many observations scheduled in March and April of 2026, we expect to confirm ~5 planets. Any confirmed planets will be among the coldest worlds known, and will be ideal targets for further atmospheric characterization with JWST. Additionally, if no planets are confirmed, it will be a strong indication that post-main-sequence evolution is more destructive than previously thought. We will present the first results from the PAWS survey, including constraints on planetary companions around nearby white dwarfs and implications for the post-main-sequence evolution of planetary systems.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

PHASE-RESOLVED TRANSMISSION SPECTROSCOPY WITH JWST REVEALS THE ASYMMETRIC ATMOSPHERE OF WASP-121B

Cyril Gapp &
Aurélien Falco (1), Thomas M. Evans-Soma (2,3), David K. Sing (4,5), Shashank Dholakia (6), Vivien Parmentier (7), Jérémy Leconte (8), Eva-Maria Ahrer (3), Guangwei Fu (5)

(1) Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Bd de l'Observatoire, CS 34229, Nice, 06304, France. (2) School of Science, University of Newcastle, Callaghan, NSW, Australia. (3) Max-Planck-Institut für Astronomie, Königstuhl 17, Heidelberg, D-69117, Germany. (4) Department of Earth & Planetary Sciences, Johns Hopkins University, Baltimore, MD, USA. (5) Department of Physics & Astronomy, Johns Hopkins University, Baltimore, MD, USA. (6) School of Mathematics and Physics, The University of Queensland, St Lucia, QLD 4072, Australia. (7) Laboratoire Lagrange, Observatoire de la Côte d'Azur, Université Côte d'Azur, Nice, 06903, France. (8) Laboratoire d'Astrophysique de Bordeaux, Univ. Bordeaux, Allée Geoffroy Saint-Hilaire, Pessac, 33615, France.

"In this talk, I will present a conclusive detection of rotational modulations of WASP-121b's transmission spectrum in observations with NIRISS and NIRSpec onboard JWST. This finding demonstrates that the transmission spectrum probes different longitudes in the planet's atmosphere as a function of orbital phase due to the planet's rotation during transit. The phase-resolved transmission spectrum reveals increased CO, but decreased H2O absorption in the planet towards the end of the transit. This firstly shows that WASP-121b's temperature structure is asymmetric about the sub-stellar point with higher temperatures in the eastern than in the western half of the dayside. And secondly, H2O depletes out of the atmosphere as hotter parts of the planet are probed while CO remains abundant thanks to its stability against thermal dissociation.
The fact that transmission spectra change as functions of orbital phase is regularly successfully applied in high-resolution spectroscopy to measure the heterogeneous structure of exoplanet atmospheres from transit observations. Yet, similar results at low spectral resolution are pending. Thus, our detection of WASP-121b's phase-dependent transmission spectrum opens up a new avenue to probe heterogeneity in exoplanet atmospheres using transit observations that is distinct from detecting limb asymmetries. This highlights the synergy between JWST and ground-based observatories, since space-based observations will be able to constrain the structure of exoplanet atmospheres in the infrared where ground-based observations suffer from increased telluric absorption."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

THE NEXT DECADE OF EXOPLANET DEMOGRAPHICS: COMPLETING THE GALACTIC CENSUS OF EXOPLANETS

Jessie Christiansen
Caltech/IPAC-NASA Exoplanet Science Institute

The next decade will see great advances in our understanding of exoplanet demographics. Data from past (e.g. Kepler/K2), ongoing (e.g. TESS, Gaia), and upcoming (e.g. Roman, Plato) surveys is covering increasingly broad planetary, stellar, and even Galactic parameter space. I will summarize the promise of each survey for exoplanet demographics – including the expected yield and parameter space – and also the challenges of self-consistently connecting them, with their different detection techniques with detection sensitivities, in different parts of parameter space. I will also describe the opportunities that arise from doing so, in particular the parameter space that will be newly accessible for addressing some of the most pressing unanswered questions in planet formation, migration, and evolution.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

DEVIATIONS FROM SOLAR ABUNDANCES FOR HOST STARS OF WIDE SEPARATION COMPANIONS AND THEIR IMPLICATIONS FOR GIANT PLANET FORMATION

Aneesh Baburaj &
Quinn Konopacky, Christopher Theissen, Roman Gerasimov, Kielan K. W. Hoch
Northwestern University, UC San Diego, UC San Diego, University of Notre Dame, Space Telescope Science Institute

JWST has enabled measurements of abundances of elements such as C, O, and even Na, S, K, and Fe in planetary atmospheres to very high precision (~0.1 dex). Host star abundances mirror the building blocks available in the planet-forming disk in which planets form, making these abundance measurements critical for accurate planet formation inferences. However, there is a significant information gap in terms of precise stellar abundances, especially for young host stars of widely-separated companions. We present results from our high-resolution spectroscopic survey of directly imaged companion host stars, measuring abundances of 16 elements (including C, O, Na, Mg, Si, S, K and Fe) for ten wide-separated companion host stars. These include primaries of systems previously observed with JWST, such as HR 8799, YSES 1, 51 Eridani, GJ 504, and beta Pic. We find solar C/O for eight host stars and sub-solar C/O ratios for PZ Tel (0.28±0.05) and beta Pic (0.22±0.06). The 4σ sub-solar C/O detections for PZ Tel and beta Pic highlight the importance of accurate stellar C/O estimates for constraining planet formation. Measurement of population-level average elemental abundances reveal super-solar carbon and oxygen for this stellar population, indicating that the protoplanetary disks around these stars were potentially rich in volatiles. These results validate theoretical models indicating that accretion of icy (volatile-rich) planetesimals during the core accretion phase reduces the atmospheric adiabatic gradient, lowering the critical core mass required for gas giant formation. Comparisons of stellar abundances to those of their companions reveal super-stellar C/O for YSES 1 b-c and beta Pic b, and super-stellar abundances for the HR 8799 planets and GJ 504 b. These findings suggest all of these objects formed via planet-like formation pathways. Our results highlight the importance of precise host star abundances for accurate interpretations of corresponding planetary abundances in the context of their formation.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

HOMOGENEOUS STELLAR PARAMETERS AS THE FOUNDATION OF EXOPLANET DEMOGRAPHICS

Sergio Sousa &
Sousa et al.
Instituto de Astrofísica e Ciências do Espaço

"Understanding exoplanet populations requires stellar parameters that are not only precise but also homogeneous across surveys and methods. Differences in spectroscopic pipelines, line lists, and modeling assumptions imprint systematic offsets on Teff, log g, [Fe/H], and detailed abundances, which then propagate into planet radii, masses, densities, and inferred compositions. Recent inter-comparisons of high-quality datasets and instruments show that methodological choices alone can shift stellar solutions, underscoring the need for unified approaches in demographic studies (Adibekyan, 2020, A&A).

I will show how the latest SWEET-Cat release built on a homogeneous EW analysis with ARES+MOOG expanded the pool of uniformly characterized FGK hosts and enabled refreshed tests of the mass-radius plane and metallicity-linked phenomena with improved internal consistency (Sousa et al., 2024, A&A 691). I will also illustrate how combining Gaia data with homogeneous stellar parameters allows one to obtain equally homogeneous planetary properties, ensuring that planet radii, masses, and derived bulk compositions rest on a consistent stellar foundation.

I will then outline several use cases where homogeneous chemical abundances add diagnostic power: for example, probing the compositional link between rocky planets and their host stars for interior inferences (e.g. Adibekyan et al., 2021, Science), or interpreting the separation between rocky and volatile-rich regimes in the mass-radius diagram (e.g. Otegi et al., 2020, A&A). For these types of studies, resources like the Hypatia Catalog (Hinkel et al., 2014, AJ; Hypatia Catalog website) remain valuable, but because they compile many heterogeneous literature sources, they inevitably encode method-to-method systematics unless further homogenization steps are applied.

Taken together, these results show that homogeneity is not a luxury: it is a requirement for establishing reliable trends in occurrence rates, the mass-radius plane, and radius inflation. I will close by suggesting a practical roadmap (shared pipelines, cross-calibration, and publicly maintained, regularly updated releases) to ensure that stellar and chemical baselines no longer limit the fidelity of exoplanet demographics."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

UNVEILING PLANETARY SYSTEMS AROUND INTERMEDIATE MASS EVOLVED STARS USING NIRPS+HARPS

Elisa Delgado Mena
Centro de Astrobiologia (CAB-CSIC)

"The number of detected planets orbiting intermediate-mass stars is still low (either detected by direct imaging when in the Main Sequence or by RV/transits when in the red giant phase). Several studies point to a sharp decrease in the planet occurrence around evolved stars more massive than ~2 Msun. This lack of planets around intermediate-mass evolved stars might be a consequence of the specificities of planet formation around such objects. Alternatively, the detection of planets around evolved intermediate-mass stars might be hindered by the increasing stellar noise as the stars evolve.
To fill this gap in the planetary zoo we carried a radial-velocity (RV) survey of young open clusters K giants, the evolved counterparts of those intermediate-mass stars. A major challenge to detect such planets is the large jitter present in these cool giants. On top of that, we have detected intriguing RV signals which mimic long-period planets (P>650 days) and are stable for periods as long as 15 years. However, it is not clear yet whether they are due to rotational modulation of active regions, long-term magnetic fields or stellar pulsations. We present the first results of a survey done with HARPS+NIRPS. The combination of high precision optical and NIR simultaneous RV points is critical to disentangle the stellar activity from the true planets and allows us to identify 3 new giant planets in different clusters and a star hosting a giant planet plus a brown dwarf or low-mass companion with a very long period. On the other hand, for the stars showing RV variations related to stellar activity we find that the amplitudes of the signals are larger in the NIR than in the optical, opposite to what expected. We discuss the possibility that these signals might be produced by stellar oscillations rather than magnetic activity."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

THE IMPACT OF MEAN MOTION RESONANCES ON THE ASTROMETRIC DETECTION OF GIANT PLANETS.

Emmanuel Greenfield &
James Owen
Imperial College London

"Analogues to the giant planets in our solar system are difficult to detect in the exoplanet context with our current observational methods. However, with new missions based on astrometry, these planets will become a prime population to study. The release of the Gaia DR4 catalogue in late 2026, detecting ~1,000-10,000 giant planets at large orbital separations, will provide the first demographic constraints on these planets' origins. However, performing demographic studies requires an understanding of detection efficiencies. One area that remains poorly explored in astrometric detections is the ability to detect multiple planets. In particular, the perturbative impact of an undetected companion on the signal of a detectable planet.

There is a prevalence of near resonant systems amongst the close-in planets we have already detected, motivating the exploration of mean motion resonances on astrometric signals. We simulate the astrometric signal from multiple giant planets through N-body integrations for systems close to and far from resonance. By fitting the astrometric signal using nested sampling, which allows a Bayes evidence comparison for single and multiple planet systems as fits to the data, I will discuss how resonances generate a regular pattern, allowing for the enhanced detection of close in giant planets and resonant pairs in the Gaia dataset.

The model preference tests that arise from nested sampling also allow us to explore a key degeneracy in astrometric detections. We use our newly developed multi-planet fitting pipeline to examine to what extent two resonant (2:1) and circular planets can generate an identical signal to a single highly eccentric planet. We find that in the ideal case of non-interacting Keplerian orbits, the degeneracy holds only for edge-on systems. We further show, using a combination of analytical arguments and simulation data, that allowing for realistic planet-planet interactions will resolve this degeneracy due to the non-zero eccentricity of the resonant planets.

Finally, I will show to what extent fitting a single planet model to a two planet resonant signal creates a bias in the data, generating a surplus of non-existent high mass high eccentricity planets. I will discuss how our Bayesian model comparison test can in most cases confirm a more accurate fit for a two planet model and similarly adjust the retrieved orbital parameters for the single planet that would otherwise be detected alone. We find a clear systematic trend for low period planets (<2 years) where this effect is particularly relevant. Thus, when demographic studies are performed on the GAIA dataset we must account for the ability of astrometric data to distinguish between single and multiple planet solution close to and far from resonance."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

SELF-ROAST: CLOSE-IN PLANET INDUCES FLARES ON ITS HOST STAR

Ekaterina Ilin &
E. Ilin (1); H. K. Vedantham (1); K. Poppenhaeger (2,3); S. Bloot (1,4); J.R. Callingham (1,5); A. Brandeker (6); H. Chakraborty (7)
(1) Netherlands Institute for Radio Astronomy (ASTRON); (2) Leibniz Institute for Astrophysics Potsdam (AIP); (3) Institute for Physics and Astronomy, University of Potsdam; (4) Kapteyn Astronomical Institute, Univeristy of Groningen; (5) Anton Pannekoek Institute (API), University of Amsterdam; (6) Department of Astronomy, Stockholm University; (7) Geneva Observatory, University of Geneva

In the past decade, hundreds of exoplanets have been discovered in extremely short orbits below 10 days. Unlike in the Solar System, planets in these systems orbit their host stars close enough to disturb the stellar magnetic field lines. The interaction can enhance the star's magnetic activity, such as its chromospheric and radio emission, or flaring. So far, the search for magnetic star-planet interactions has remained inconclusive. In this talk, I present the first detection of planet-induced flares on HIP 67522, a 17 million-year-old G dwarf star with two known close-in planets. Combining space-borne photometry from TESS and dedicated CHEOPS observations over a span of 5 years, we find that the 15 flares in HIP 67522 cluster near the innermost planet's transit phase, indicating persistent magnetic star-planet interaction in the system. The stability of interaction implies that the innermost planet is continuously self-inflicting a six times higher flare rate than it would experience without interaction. The subsequent flux of energetic radiation and particles bombarding HIP 67522 b may explain the planet's remarkably extended atmosphere, recently detected with the James Webb Space Telescope, potentially doubling its mass loss rate. Our results establish HIP 67522 as the archetype system for flaring star-planet interaction, and urge further characterization of the dynamic magnetism of this and similar star-planet systems.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

COMMON ENVELOPE EVOLUTION PRODUCES RARE, MASSIVE, CLOSE-IN PLANET SURVIVORS

Yadira Gaibor &
Andrew Vanderburg (1,2), Juliette Becker(3), Melinda Soares-Furtado(3), and Tansu Daylan(4)

MIT, (1) Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA. (2)Center for Astrophysics Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA. (3) Department of Astronomy, University of Wisconsin-Madison, 475 N. Charter St. Madison, WI 53706, USA. (4) Department of Physics and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, USA

The discovery of WD 1856b—a giant planet orbiting a white dwarf—uniquely challenges our understanding of planetary survival through stellar evolution. Common Envelope (CE) evolution is one of the proposed formation mechanisms that could shape the orbital architecture of these planets around stellar remnants. We investigate the feasibility of CE evolution as the primary channel for producing close-in planets around white dwarfs.
We simulate a population of giant planet hosts by sampling initial conditions from observed mass and orbital period distributions. We evolve the host star from main sequence to white dwarf to assess which planetary configurations could survive and we predict the resulting post-CE planet population. Our results suggest that CE evolution can, in principle, produce such systems, but it is likely a rare outcome. We find that most of the surviving planets have >9 Jupiter mass and orbital separations of <0.007AU. We discuss the implications of our results for the growing population of white dwarf planet candidates and outline observational signatures of CE survivors.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

INFLATION OR INFERENCE? REVISITING THE M DWARF RADIUS INFLATION PROBLEM WITH ECLIPSING BINARIES

Yasmin Davis &
Amaury Triaud, The EBLM Project
University of Birmingham

“M dwarfs are prime targets in the search for Earth-like exoplanets. However, despite their abundance, they remain comparatively poorly characterised. Their intrinsic faintness and complex features make precise observational constraints on their physical properties challenging, resulting in larger than desired uncertainties in their fundamental stellar parameters. For exoplanet host stars, this limitation is particularly consequential, as the stellar masses and radii inferred from evolutionary models are propagated directly into derived planetary properties. In the low-mass regime, questions remain regarding the validity of these models due to the scarcity of empirically characterised stars, raising concerns about potential systematic biases, most notably the long-debated issue of M-dwarf radius inflation.

Low-mass eclipsing binaries (EBLMs) provide a unique opportunity in this regime, enabling direct measurements of stellar masses and radii. By combining space-based photometry with high-resolution ground-based spectroscopy, we exploit the complementary strengths of each method to achieve highly precise and accurate stellar radii measurements. Our homogeneous sample is comprised of over 50 M-dwarf stars ranging from 0.1 to 0.6 Msun, with an average precision of 1.4% on stellar radius.

At this unprecedented level of precision, methodological and statistical choices become critical when comparing measured parameters to stellar evolution models. In the past, most work considered uncertainties either in radius, or in mass, but rarely in both. However, with the substantially improved empirical precision we achieve, we needed to develop a new metric to quantify stellar radius inflation accounting for uncertainties in radius and mass, as well as the correlation between them.

Using our new inflation metric I will present results from the largest homogeneous study of EBLMs to date. With this approach, we find no evidence for M dwarf radius inflation within the sample. We measure that on average stars between 0.1 and 0.6 Msun have radii 0.3 ± 1.6% larger than models would predict. Our results therefore strongly support the current low-mass stellar evolution models, demonstrating their ability to accurately reproduce the structure of M-dwarf stars, and improving confidence in model-based parameter estimates for single exoplanet host stars.”

INTRINSIC LIMITATIONS TO TEMPLATE-BASED RADIAL VELOCITY EXTRACTION FROM HIGH-RESOLUTION SPECTRA

André Silva &
Etienne Artigau, Khaled Al Moulla, Nuno Santos, Dhvani Doshi, Jorge Martins, Pedro Viana, Sérgio Sousa

Instituto de Astrofísica e Ciências do Espaço; Fac. Ciências da Uni. Porto; Institut Trottier de recherche sur les exoplanètes; Observatoire du Mont-Megantic, Uni. de Montreal; Department of Physics, McGill University; Trottier Space Institute, McGill University

"In radial velocity (RV) surveys and in the follow-up of transiting exoplanets, observations are carried out over multiple months. This allows to properly sample the orbital period of the orbiting companions and to characterize any stellar signals. However, several science cases—such as atmospheric characterization via transmission or emission spectroscopy, or asteroseismology—require high-cadence observations acquired over much shorter timescales, often limited to a single night or a few consecutive nights.
In this talk, we will present two previously unidentified biases in extracted RVs when using template-based algorithms.
The first effect is linked to the construction of stellar templates from observations collected within a short time-span. The presence of this bias is shown in two template matching pipelines, present in the data of multiple state-of-the-art spectrographs, with varying amplitudes across different stars. We demonstrate that the effect can be recovered on a larger sample of 19 targets, totaling 4124 ESPRESSO observations spread through 38 nights. In this sample, we consistently find a systematic quasi-linear bias affecting the RV extraction with typically negative slopes up to sim -52 m/s/h. We hypothesise that contamination from microtelluric features or other fixed pattern noise is the likely root cause of this effect, which could have implications for high-precision RV studies, particularly in short-timescale observing campaigns.
The second effect arises from the interpolation of stellar spectra that is common in such methods, with a more pronounced effect on short time-span observations. We show that on ESPRESSO observations taken over a few days, the effect can reach 1 m/s in high signal-to-noise (SNR) datasets, and up to 25 m/s in low SNR cases. When the data is collected over a larger temporal window, over multiple months, we place the upper ceiling of this effect to be 20 cm/s through real ESPRESSO observations.
The interplay between these effects thus translate into a significant challenge to be surpassed, not only for RV analysis, but also for other science cases that rely on such data-driven stellar models."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

TOWARDS DETECTING EARTH-TWINS: COMBINING OPTIMISED RV EXTRACTION WITH STELLAR-VARIABILITY MITIGATION

Ancy Anna John &
Annelies Mortier, Andrew Collier Cameron, Ben Lakeland, Joao P Faria
University of Birmingham, University of St Andrews, Geneva Observatory

As next-generation spectrographs approach the sub-m/s regime precision, the dominant barrier to detecting Earth analogues is no longer instrumental noise but the intrinsic variability of stars themselves. Overcoming this challenge demands new approaches to RV extraction and stellar-activity mitigation. Achieving the radial-velocity (RV) precision required to detect Earth-like, low-mass exoplanets demands modelling stellar signals at the 10 cm/s level. However, stellar variability – driven by surface inhomogeneities – currently limits RV precision to around 1 m/s, even with state-of-the-art spectrographs. Reaching the next precision frontier therefore requires advances in data reduction and analysis alongside instrumental development. Traditional RV extraction methods rely on cross-correlation functions (CCFs) derived from generalised line masks, but these masks are not tailored to individual stellar spectra. Variability-mitigation frameworks such as SCALPELS, which separate stellar activity-induced CCF-shape distortions from genuine Doppler shifts, have already demonstrated improvements to ~50 cm/s precision. Here, I present MMLSD, an RV extraction method that uses star-specific theoretical line masks from the VALD3 database combined with least-squares deconvolution (LSD) to generate optimised common line profiles. The root-mean-square (RMS) scatter of RVs derived with MMLSD consistently outperforms that obtained with standard CCFs. By applying SCALPELS to MMLSD profiles, we achieve a ~37% reduction in RV RMS using Solar training data, as well as comparable improvements on stellar targets. Tests on the archival spectra of systems with known planetary companions further show enhanced detection precision under the combined MMLSD + SCALPELS approach. This combination of optimised line masks and advanced variability mitigation represents a promising step toward the RV precision necessary for detecting true Earth analogues.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

REACHING 40 CM/S RV PRECISION ON HARPS-N SOLAR DATA WITH A PCA CORRECTION AT THE SPECTRAL LEVEL

Sara Tavella &
Xavier Dumusque, Michael Cretigner
University of Geneva, Oxford University

"While a radial velocity (RV) precision of 10 cm/s is required to detect an Earth analogue, state-of-the-art analysis techniques are still limited to ~1 m/s for main-sequence stars due to residual instrumental and stellar perturbations. These signals are difficult to disentangle and mitigate at the level of RV time series and through CCF-based indicators, as they get mixed together when the information content of the full spectra is compressed into only a few parameters. We therefore propose to perform the corrections upstream, directly at the level of the spectra, by examining flux fluctuations over time in the individual wavelength bins. Here, wavelength-dependent features of instrumental, stellar, and telluric origin are often larger than in the RVs and easier to distinguish. Moreover, the RV precision reached within a single wavelength bin is at most a few tens of m/s, which prevents the detection and absorption of low-amplitude planetary signals during the correction process. The YARARA framework (Cretignier et al. 2021), developed with this idea in mind, has already shown remarkable results in correcting well-known instrumental systematics and stellar activity. We further extend this method by mitigating residual contaminations in the spectra through a PCA-based analysis. Using this technique, we are able to reduce the RV rms of the first 8 years of HARPS-N solar observations down to 40 cm/s. In the PCA-corrected RVs, injected planetary signals as low as 30 cm/s are robustly recovered, setting a detection limit of ~2.5 $M_\oplus$ at 1 year orbit. Preliminary results show that this approach can be extended to other extensively observed stars with spectral signal-to-noise ratios of a few hundred – high but achievable for bright nearby targets."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

RADIAL-VELOCITY VARIABILITY OF THE MAGNETICALLY QUIET SUN

Ben Lakeland
University of Birmingham

"With the advent of extreme-precision radial-velocity (RV) spectrographs capable of sub-m/s precision, overcoming the intrinsic variability of the host star has become the main hurdle to detecting low-mass long-period planets.
A wide range of techniques has been developed to mitigate the impact of stellar variability. Most of these can effectively correct the RV variability coming from isolated magnetically active regions on the stellar surface.
Using SDO and HARPS-N Sun-as-a-star observations, I have characterised the RV variability emerging from outside these isolated regions.
In this talk I will show that the magnetically inactive solar surface has a consistent level of variability throughout the magnetic cycle at the level of 1m/s, often far exceeding the RV variability from the active regions.
I will highlight the different sources of this constant variability with supergranulation, which currently can not be mitigated, identified as being the dominant driver."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

THE SMALL PLANET-COLD JUPITER CONNECTION: DEMOGRAPHIC INSIGHTS FROM A TARGETED RV SURVEY AND THE HD 29021 SYSTEM

Matteo Pinamonti &
Domenico Barbato

INAF – Osservatorio Astrofisico di Torino, INAF-Osservatorio Astronomico di Padova

"The relationship between inner low-mass planets and outer giant companions provides a key observational test of competing models of planet formation and dynamical evolution. In particular, it remains unclear whether cold Jupiters (CJ) suppress, promote, or coexist with the formation of close-in small planets (SP). To address this question, we have conducted an intensive targeted radial-velocity (RV) survey with the HARPS-N and FIES spectrographs, focused on nearby stars hosting long-period GPs, searching for previously unseen short-period low-mass companions.

We present the main results of this program, highlighting HD 29021 as a benchmark system. By combining our new HARPS-N and FIES measurements with additional HARPS-N RVs from the GAPS collaboration, we identify two compelling short-period low-mass planet candidates interior to the known super-Jupiter. The planets have orbital periods of Pc = 2.67 d and Pd = 5.94 d, and minimum masses of Mcsini = 2.52 M⊕ and Mdsini = 2.76 M⊕. The signals are consistently recovered across instruments and observing epochs, and are not correlated with stellar activity indicators, supporting a planetary origin. The two inner companions have similar masses and compact orbital spacing, consistent with the "peas-in-a-pod" architecture commonly observed in tightly packed multi-planet systems discovered by Kepler and TESS. This suggests that the formation pathways producing uniform, compact super-Earth systems may remain effective even in the presence of an outer giant planet.

The architecture of HD 29021 — compact inner low-mass planets coexisting with a massive outer giant — provides a concrete example of the system class targeted by our survey. We place this detection in the broader context of recent statistical studies of super-Earth occurrence in cold-Jupiter systems, discussing how our results inform scenarios of planet migration, disk evolution, and the efficiency of inner planet formation in the presence of outer giants. Moreover, we explore how the spectral type of the host star influences the joint formation of inner SPs and GPs.

Our findings provide new constraints on how cold Jupiters and inner small planets form and interact, helping to refine theoretical models of planetary system formation and to characterize the demographics of multi-planet systems. Ultimately, our work highlights the essential role of targeted RV monitoring in decoding the complex demographic links that shape the architecture of planetary systems across the solar neighborhood."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

BLIND SEARCHES FOR EXOPLANETS WITH NIRPS: RESULTS, LIMITS, AND SYNERGIES.

Salomé Grouffal &
NIRPS consortium
CNRS – IPAG

"The Guaranteed Time Observations (GTO) programme of the Near Infra Red Planet Searcher (NIRPS) has now been ongoing for nearly three years, with close to one third of the observing time dedicated to blind searches for exoplanets around low-mass stars. Operated simultaneously with HARPS on the ESO 3.6-m telescope, NIRPS now reaches performance levels beyond initial expectations, opening access to particularly challenging regimes that were previously out of reach and redefining what can be achieved with a 3.6-m class facility.
Using Proxima Centauri as a benchmark, we conducted an intensive monitoring campaign over two observing seasons and successfully recovered the two previously known planets, including the lower-mass signal that had so far only been detected with ESPRESSO on an 8-m telescope. In parallel, the blind-search programme has revealed a growing number of additional very low-mass planet candidates around some of the nearest M dwarfs, identifying prime targets for future atmospheric characterisation with upcoming facilities such as the ELT.
The simultaneous use of NIRPS and HARPS enables a new approach to stellar activity mitigation, a key limitation for M-dwarf planet searches. By exploiting the chromatic dependence of radial-velocity signals and combining optical and near-infrared activity indicators, this strategy provides powerful new diagnostics to disentangle planetary signals from stellar variability.
This contribution presents a synthesis of the detection limits, methodological advances, and observational strategies enabled by NIRPS, and discusses the key synergies with forthcoming missions and facilities, including PLATO, Gaia DR4, and the ELT. Together, these developments illustrate the central role that NIRPS can play in the discovery and preparation of small exoplanets for future detailed characterisation."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

LARGE-SCALE EXOPLANET SCIENCE CASES WITH PHOTONIC E-MARCOT

Francisco J. Pozuelos &
Photonic E-MARCOT consortium
Instituto de Astrofísica de Andalucía (IAA-CSIC)

“Photonic E-MARCOT is conceived as a next-generation ground-based facility following a large-scale survey philosophy, designed to transform the current abundance of exoplanet detections into robust, population-level physical characterisation. By combining a modular, flux-collecting multi-telescope architecture with advanced astrophotonic technologies, the project enables high-resolution spectroscopy at efficiencies unreachable with classical single-aperture designs. Photonic E-MARCOT is optimised for the systematic and homogeneous characterisation of planets, addressing both ultra-precise radial-velocity measurements and atmospheric studies through high-resolution transmission spectroscopy. The facility is planned through a phased implementation, with a first science phase equivalent to a 5-m class collecting area, followed by a second phase reaching the equivalent of a 15-m aperture. An operational Pathfinder acts as a technology validator for the proposed photonic concepts and instrumental architecture. In this talk, we present end-to-end simulations demonstrating the capability of Photonic E-MARCOT to perform large-scale, homogeneous determinations of exoplanet internal composition through ultra-precise radial-velocity measurements combined with transit constraints, as well as to systematically characterise atmospheres via high-resolution spectroscopy. This dual approach enables, for the first time, population-level studies linking interior structure and atmospheric properties across a wide range of exoplanet classes.
In the post-ELT era, Photonic E-MARCOT is positioned as an exoplanet-dedicated facility, providing homogeneous datasets required to understand the physical processes governing planet formation, evolution, and habitability.”

THE SEARCH FOR SUPERGRANULATION ACROSS SPECTRAL TYPES

Niamh O'Sullivan
University of Oxford

In recent years supergranulation has emerged as one of the biggest challenges for the detection of Earth-twins in radial velocity (RV) planet searches. Supergranulation introduces RV variations on timescales of 1-2 days with amplitudes of 0.5-1 m/s, considerably larger than the expected 10 cm/s signal from Earth-like planets. I will present work into searching for supergranulation's RV and spectral signature in stars other than the Sun for the first time. Looking at archival asteroseismic campaigns I will show how we have characterised supergranulation in a handful of stars, and how this can help us start our search for a supergranulation spectral indicator. I will demonstrate the need for dedicated supergranulation observational campaigns and talk about the Terra Hunting Experiment's potential SHE survey, one of the first of these campaigns, and the preparations taken for it.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

HABITABLE WORLDS OBSERVATORY PROJECT STATUS & MATURATION PLANS

David Charbonneau &
Aki Roberge
Harvard University, NASA Goddard Space Flight Center

"Humans have long wondered if there were worlds around other stars – and life on those worlds. Over the last decades, astronomers have found that the answer to the first question is a resounding YES. Those accomplishments have put us in a position to possibly answer the second question. The 2020 Astrophysics Decadal Survey laid out a path to the first telescope that can find out if habitable exoplanets are common or rare and search them for signs of global biospheres. At the same time, this UV / optical / near-IR space observatory would perform a wide range of transformative astrophysics studies from galaxy evolution to star formation – and be capable of a wide range of powerful Solar System remote sensing observations.
NASA has named that space telescope the Habitable Worlds Observatory (HWO) and initiated the HWO Technology Maturation Project Office on Aug 1, 2025. This presentation will provide an overview of the current project status; progress on potentially driving science cases, engineering trade studies, and technology development; and plans for upcoming activities & milestones."

ROOM 3
29/06 14:15–14:30

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

DETECTING BIOSIGNATURES ON HABITABLE ROCKY WORLDS WITH ELT/ ANDES

Aaron Bello-Arufe &
Evann Kurzawa Ferrandez (1), Renyu Hu,(1, 2, 3, 4)

1: Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA// 2: Department of Astronomy & Astrophysics, The Pennsylvania State University, University Park, PA 16802, USA// 3: Center for Exoplanets and Habitable Worlds, The Pennsylvania State University, University Park, PA 16802, USA// 4: Institute for Computational and Data Science, The Pennsylvania State University, University Park, PA 16802, USA

"The search for life beyond the Solar System is at a turning point, transitioning from theoretical predictions to observations enabled by next-generation observatories. The Extremely Large Telescope (ELT) will host the ArmazoNes high Dispersion Echelle Spectrograph (ANDES), optimized for visible to near-infrared high-resolution spectroscopy. We present an end-to-end simulation–detection pipeline to evaluate the ability of ANDES to detect CO_2, H_2O, and potential biosignature gases O_2 and CH_4 in the transmission spectra of potentially habitable rocky exoplanets. Assuming cloud-free, modern Earth-like atmospheres, we model the transmission spectra using realistic noise estimates from the ANDES Exposure Time Calculator. We introduce a novel Bayesian cross-correlation function (CCF) framework that incorporates molecule-specific kernels and a new autoregressive model to account for correlations in the CCF. We apply our framework to 19 potentially habitable transiting exoplanets observable with the ELT and estimate the number of transits required for a very strong detection (Delta B > 1.5$).
We find that CH_4 and H_2O are the most accessible species, potentially detectable in <~2 transits for TRAPPIST-1 d. CO_2 requires at least ~30 transits in the most favorable target, TRAPPIST-1d, whereas O_2 remains undetectable in <50 transits. For eight planets (TRAPPIST-1d, e, f, g; K2-288 B b; LHS-1140 b, and TOI-700d, e), at least one gas may be detectable in <~ 100 transits.
Because our framework assumes favorable observing conditions and perfect data detrending, the estimates here should therefore be interpreted as best-case scenarios but provide an initial benchmark for the search for biosignatures with ANDES."

DECODING OTHER WORLDS: UNLOCKING PLANETARY HABITABILITY AND ATMOSPHERIC BIOSIGNATURES WITH THE LIFE SPACE MISSION

Sascha P. Quanz &
The LIFE Space Mission project team
ETH Zurich

"The quest to identify habitable environments and potential atmospheric biosignatures on temperate, terrestrial exoplanets is a primary driver of modern astrophysics. Targeting a launch no later than 2040, the LIFE Space Mission is designed to access the mid-infrared (MIR) thermal emission of these worlds which is essential for a holistic understanding of planetary atmospheres and surface conditions. Determining the habitability of a planet requires more than just confirming its size and orbital position; it necessitates an analysis of its atmospheric composition and temperature structure. Crucially, the MIR contains key absorption lines of the most diagnostic atmospheric species for assessing habitability and identifying biosignature gases. Also, by measuring the thermal flux directly, LIFE breaks the degeneracy between planetary radius and albedo, providing a direct measurement of a planet's effective temperature.

The primary science goal of the LIFE Space Mission is to search for atmospheric biosignature gases in at least 55 temperate, terrestrial exoplanets orbiting nearby main sequence stars with spectral types between mid-F and late-M. By operating in the 4—18.5 μm range, the mission aims to detect critical molecules including—but not limited to—CO2, H2O, O3, and CH4. This allows for the assessment of greenhouse effects, the presence of liquid water, and the search for atmospheric chemical disequilibrium—a key indicator of potential biological activity.

In this talk I will present the overarching motivation behind the LIFE Space Mission, detail the Science Objectives, and discuss the current Mission Reference Design. Further, I will highlight ongoing technology development efforts and present the current plan to bring the mission from concept to launch. As we move toward the next decade of exoplanet exploration, the LIFE Space Mission represents the most viable path to characterizing the atmospheric properties and surface conditions of the nearest— possibly living—worlds."

EXO-EARTH SCIENCE WITH HABITABLE WORLDS OBSERVATORY

Tyler Robinson
University of Arizona

The under-development NASA Habitable Worlds Observatory (HWO) will transform the study of exoplanetary environments. Importantly, HWO will be specifically designed to detect and characterize truly Earth-like worlds orbiting our nearest Sun-like neighbors. Thus, HWO represents an opportunity to define, from the start, a flagship observatory capable of detecting signs of habitability and life from rocky worlds. Current exo-Earth science for HWO emphasizes reflected light observations spanning ultraviolet, optical, and near-infrared wavelengths, which provide access to spectral features from key gases like water vapor, molecular oxygen, ozone, and carbon dioxide. Several recent works now show that moderate-quality observations at low/medium resolving powers for Earth-like worlds at various evolutionary stages empower the detection of biosignature gases alongside other constraints on the planetary environment. Ongoing exo-Earth intercomparison efforts focused on forward and inverse modeling tools bolster these results. Nevertheless, challenges to the mission paradigm remain. First, different conclusions have been reached in the literature with respect to the value of having a mass prior for HWO's exo-Earth targets. More specifically, it is unclear how the measurement of a planetary mass (e.g., using extreme precision radial velocity techniques) influences atmospheric retrievals for Earth-like worlds. Second, the direct detection of surface liquid water relies on challenging observations of either/both polarimetric phase curves and ocean specular reflection (i.e., glint). Ongoing observations of our own Earth indicate have proven that these approaches to the remote sensing of surface habitability can yield ambiguous interpretations. Finally, and perhaps most obviously, is the technical challenge of building an observatory capable of acquiring exoplanet observations in the regime of planet-to-star flux ratios measured in the parts-per-ten-billion level. This presentation will provide an overview of development efforts for HWO and will also discuss the challenges of interpreting reflected-light spectra of Earth-like worlds.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE ROCKY WORLDS DDT PROGRAM

Nestor Espinoza &
Hannah Diamond-Lowe, Munazza Alam, Taylor Bell, John Debes, Leonardo Dos Santos, Ryan Kunzer, Tyler Baines, Hannah Braun, Kyle Conroy, Rachel Cooper, Misty Cracraf, Achrene Dyrek, Joseph Filippazzo, Mees Fix, Julie Imig, Douglas Long, Joshua Lothringer, Kelly Lepo, Elena Manjavacas, Brett Morris, Leonardo Ubeda, Ian Wong, Rachel Plesha

Space Telescope Science Institute, Baltimore, MD

One of the key questions in exoplanetary science is whether rocky exoplanets orbiting M-dwarfs can retain their atmospheres, and under what conditions this is possible. The Rocky Worlds Director's Discretionary Time (DDT) Program is a coordinated 250-orbit Hubble Space Telescope (HST) and 500-hour James Webb Space Telescope (JWST) effort designed to address this question, representing the largest joint HST+JWST exoplanet program to date. The program targets nine rocky exoplanets spanning equilibrium temperatures from ~220 to 580 K, combining JWST/MIRI 15 μm secondary-eclipse photometry to search for exoplanet atmospheric signatures with HST/STIS and COS observations to characterize the ultraviolet environments of their host stars. In this talk, I will present the scientific motivation and observing strategy of the program, showcasing how this multi-wavelength approach is key to enabling direct tests of atmospheric retention and heat redistribution on rocky planets. I will also present the first results from the program, including early constraints on dayside emission and atmospheric properties for the initial targets, and discuss how the full dataset will inform population-level trends and provide a long-term legacy resource for the community.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

HOT ROCKS THROUGH JWST/NIRSPEC'S EYES: WHAT WE LEARNED FROM PHASE CURVES

Qiao Xue
University of Chicago

"Rocky planets orbiting M dwarfs lie at the frontier of characterizing exoplanet atmospheres: they are the most common planets in our universe, and their planet-to-star radii ratio makes them highly favorable for observation follow-ups. However, intense stellar irradiation can strip primordial volatiles, and the threshold at which atmospheres are lost in these worlds remains uncertain. Detecting atmospheres on rocky planets around rocky planets around M dwarfs through secondary-eclipse measurements with JWST's Mid-Infrared Instrument (MIRI) is a central goal of multiple GO programs and the ongoing Rocky Worlds DDT program.

In this talk, we present results for two rocky planets that probe a previously unexplored range in irradiation (Tirr) space—TOI-2445 b and TOI-1685 b. We obtained full-orbit JWST/NIRSpec phase curves with PRISM for TOI-2445 b and G395H for TOI-1685 b. The blue end of PRISM (0.5–2 μm) provides a simultaneous reference for stellar variability. The correction dramatically improves sensitivity to planetary signals. This technique demonstrates how PRISM's wide wavelength coverage can be leveraged to disentangle stellar contamination from the underlying planetary emission.

From phase curves, we retrieve dayside and nightside brightness temperatures for both planets, constraining their albedos and heat redistribution efficiencies, which are key diagnostics for the presence or absence of an atmosphere. Unlike single-eclipse measurements, these continuous phase curves can break the surface–atmosphere degeneracy. Furthermore, we report tentative evidence for specific surface compositions from the emission spectrum, providing a rare glimpse into the geology of highly irradiated rocky worlds.

Finally, we place these results in a population context by combining our NIRSpec phase curves with existing MIRI/LRS, imaging and DDT data on rocky planets. Together, the data will map out a more complete brightness temperature – Tirr space, guiding future atmospheric searches on JWST and beyond."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

INFRARED HEATING HAMPERS HABITABILITY AROUND M STARS

Ryan Boukrouche &
Neil Lewis, Rodrigo Caballero
University of Southampton, University of Exeter, University of Stockholm

Our search for habitable worlds is heavily biased toward transiting planets orbiting M-class stars due to our current instrumental constraints. Although M-class stars are much more abundant than Sun-like G-class stars, their relatively high activity and XUV radiation combined with the close proximity of orbiting planets may prevent habitability outright. In this talk, I will show that even without such harmful stellar activity, M stars still present an intrinsic challenge for habitability. I will present the results of a large series of Global Climate Model simulations exploring the impact of the spectral energy distribution of M and G host stars on the climate dynamics of tidally locked exoplanets, before and through the onset of the runaway greenhouse effect. The infrared content of the incoming stellar flux has a first-order effect on the climate dynamics, cloud distribution, and habitability prospects. Clouds are particularly critical in setting the location of the inner edge of the habitable zone, and using different cloud schemes has more impact than the surface albedo. I will present the mechanisms involved and discuss the implications for future observation efforts. This work represents an important step toward a deeper physical understanding of terrestrial habitability and reassesses the most promising targets for upcoming observatories.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

A BIOLOGICALLY DEFINED HABITABLE PHASE SPACE FOR EXOPLANETS

Afonso Mota &
Nuno Santos (1,2), Catarina Magalhães (3,4), Adrienne Kish (5), and Marta Cortesão (2)

1 – Instituto de Astrofísica e Ciências do Espaço, CAUP, Universidade do Porto, Porto, Portugal; 2 – Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal; 3 – Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), Universidade do Porto, Porto, Portugal; 4 – Departamento de Biologia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal; 5 – Muséum national d'Histoire naturelle (MNHN), Paris, France

"The concept of habitability in exoplanet science is still largely defined by astrophysical boundary conditions, particularly the hypothetical presence of surface liquid water within a circumstellar habitable zone. Most approaches rarely incorporate quantitative biological constraints. Here, we present a biologically grounded approach to exoplanet habitability based on the measured growth limits of terrestrial microorganisms, and show how integrating these data can refine and extend current habitability concepts.
Building on a large-scale meta-analysis of cultured prokaryotic microorganisms, we define a multidimensional phase space of habitability describing the combinations conditions that allow sustained microbial growth, rather than only survival. Long-term biosphere persistence and detectability through biosignature production require active metabolism and replication, while survival alone is only relevant under transient or episodic conditions. Within this framework, habitability is evaluated across key conditions, such as temperature, radiation environment, oxygen availability, pH, and salinity. Using growth-based limits, we build empirical habitable ranges that can be mapped onto planetary surface and subsurface environments predicted by exoplanet climate and interior models. The growth temperature ranges were also used to define biologically-constrained habitable zones.
Finally, we outline how these empirically derived biotic habitable zones can be combined with stellar, planetary, and atmospheric models to define revised habitability criteria for exoplanets, moving from water-based to life-informed approaches. This work provides a quantitative bridge between microbiology and exoplanet science, and a step toward biologically realistic assessments of habitable worlds."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

ATMOSPHERE AND TIDAL DEFORMATION OF WASP-103B FROM ITS JWST/ NIRSPEC-PRISM PHASE CURVE

Susana Barros &
Babatunde Akinsami, Monica Lendl
Instituto de Astrofísica e Ciências do Espaço, University of Geneva

"WASP-103b is an iconic ultra-hot Jupiter in an extreme star–planet interaction regime. Using high-precision transit photometry, we previously measured the planet's non-spherical (tidally deformed) shape, enabling an initial constraint on its Love number and thus a first probe of its interior structure. However, the precision achieved so far has not been sufficient to tightly constrain the planet's internal structure.
We present preliminary results from a full-orbit JWST/NIRSpec-PRISM spectroscopic phase-curve observation of WASP-103b (optical to near-infrared wavelengths, in a single continuous visit). This dataset provides an unprecedented view of a strongly tidally influenced exoplanet and offers a unique opportunity to connect atmospheric circulation and tidal physics in one system. From the phase-resolved signal, we measure hotspot offsets and quantify the planet's heat redistribution efficiency; we also test for wavelength dependence of these phase-curve properties within current uncertainties, probing the impact of extreme irradiation on longitudinal temperature gradients.
Beyond atmospheric characterisation, the phase-curve morphology of WASP-103b carries signatures of tidal deformation, providing important context for understanding how intense star–planet interactions shape both atmospheric dynamics and planetary evolution. The talk will discuss the power of JWST full-orbit spectroscopy to connect atmospheric circulation and tidal physics in extreme exoplanets and establish WASP-103b as a benchmark target at the intersection of exoplanet atmospheres and interiors."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE BEST OF BOTH WORLDS: NIRSPEC PRISM PHASE CURVES OF TWO HIGH-MASS HOT JUPITER ANALOGS

Daphne Broski-Laing &
Y. Zhou (1); J. French (2); L. Shin (3); D. Apai (3); S. Casewell (4); B. W. P. Lew (5); J. Lothringer (6); M. Marley (3); L. C. Mayorga (7); V. Parmentier (8); X. Tan (9); S. Xu (10)

(1) Univ. of Virginia; (2) Univ. of Birmingham; (3) Univ. of Arizona; (4) Univ. of Leicester; (5) Bay Area Environmental Research Institute; (6) Space Telescope Science Institute; (7) The Johns Hopkins Univ. Applied Physics Laboratory; (8) Univ. Cote d'Azur; (9) Shanghai Jiao Tong Univ.; (10) NOIRLab – Gemini North (HI)

"Short-period white dwarf-brown dwarf binaries (WD-BDs) provide a key observational link between isolated brown dwarfs and irradiated planets. The brown dwarfs are rapid rotators, comparable to Jupiter and Saturn, and their three-dimensional temperature structures are shaped by both a hot Jupiter-like irradiation environment and the convective heat flux emerging from their interiors. These systems serve as powerful laboratories to probe atmospheric dynamics in a critical parameter space for substellar and planetary atmospheres, while their unique formation histories provide a rare glimpse into the evolution of planetary systems around post-main-sequence stars.

We present JWST NIRSpec PRISM phase curve observations of two WD-BDs, ZTFJ0038+2030 and WD0137. Both systems offer an unprecedented view into the atmospheres of irradiated substellar objects with the wavelength coverage and precision that is only accessible with JWST. Our observations of ZTFJ0038+2030 probe the dynamics of a brown dwarf with Saturn-like rotation speeds and atmospheric features that closely resemble isolated brown dwarfs. In contrast, WD0137 exemplifies a substellar atmosphere's behavior pushed to an extreme due to its rapid rotation and intense irradiation. The remarkable data quality motivates a novel joint atmospheric retrieval technique to probe the longitudinal and vertical temperature structures of an irradiated atmosphere. We present precise constraints on the atmospheric circulation and fundamental parameters of these compelling hot-Jupiter analogs, with direct implications for our understanding of planetary atmospheric dynamics and planetary system evolution around evolved stars."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

RESOLVING THE ATMOSPHERIC LIMBS OF HD 209458B WITH JWST/NIRCAM

Eva-Maria Ahrer &
Cathal Maguire
Max Planck Institute for Astronomy, University of Bristol

"With JWST we now have the necessary precision in the transit light curves as well as large wavelength coverage to detect differences in the atmospheric limb spectra of hot Jupiters. This allows us to identify local cloud coverage and temperature changes in the planets' atmospheres between the morning (leading) and evening (trailing) limb.
Here we will present the first limb asymmetry study of the canonical hot Jupiter HD 209458b, identifying these differences between the morning and evening side of the planet's atmosphere using NIRCam F322W2 and F444W data (Xue et al., 2024). We apply both limb asymmetry extraction frameworks Catwoman (Jones & Espinoza, 2021; two semi-circles) and Harmonica (Grant & Wakeford, 2023; transmission strings) to the NIRCam light curves of HD 209458b and measure the planet's atmospheric absorption varying across the two terminator regions.
Since attributing variations during ingress or egress to true limb asymmetries requires accurately known system parameters, our work further includes newly refined system parameters for HD 209458b using 20 years of archival transit and radial velocity data as well as the JWST light curves.
Thus, our study determines the morning and evening spectrum of HD 209458b and ensures robust atmospheric results by testing two independent limb-asymmetry analyses under both circular and eccentric orbital assumptions, investigating biases introduced by the differing limb-asymmetry analysis techniques and assumed system parameters."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

BREAKING DEGENERACIES IN THE PHASE CURVES OF THE ULTRA-HOT JUPITER WASP-121B WITH JWST NIRISS AND NIRSPEC

Jared Splinter &
Louis-Philippe Coulombe, Robert Frazier, Nicolas Cowan, Emily Rauscher, Stefan Pelletier, Ryan MacDonald, Lisa Dang, David Lafreniere and the NEAT Team

McGill University, Trottier Institute for Research on Exoplanet, University of Michigan, Trottier Space Institute at McGill, Observatoire astronomique de l'Universite de Geneve, University of St. Andrews, University of Waterloo

"Ultra-hot Jupiters, with dayside temperatures rivaling those of low-mass stars, serve as natural laboratories for studying atmospheric circulation, chemistry, and energy transport under extreme irradiation. We present a comprehensive analysis of the ultra-hot Jupiter WASP-121b using for the first time combined spectroscopic phase curves from the James Webb Space Telescope (JWST) NIRISS/SOSS and NIRSpec/G395H instruments, spanning 0.6–5.17 μm, enabling phase-resolved constraints on atmospheric temperature, composition, and chemical disequilibrium across the day–night boundary.
The JWST/NIRSpec G395H phase-curve of WASP-121b revealed a chemically complex and spatially heterogeneous atmosphere, including detections of H_2O, CO, SiO, and CH_4, with super-stellar elemental ratios inferred on the dayside and the detection of methane on the nightside. These results highlight the role for pebble and planetesimal accretion during formation, alongside strong dynamical processes such as vertical mixing on the nightside. However, the interpretation of these abundances is complicated by the limited wavelength coverage of NIRSpec alone, particularly for key opacity sources that dominate at shorter wavelengths such as TiO and VO.
In this work, we apply spectral retrieval techniques to the full set of phase-resolved emission spectra by jointly analyzing the NIRISS/SOSS and NIRSpec/G395H observations. The addition of the NIRISS wavelengths substantially improves sensitivity to key opacity sources—including FeH, TiO, VO, H^-, and H_2O—that dominate the optical and near-infrared and strongly influence the thermal structure and emergent spectra of ultra-hot Jupiters. This broad wavelength coverage enables tighter constraints on global abundance ratios and temperature–composition degeneracies, and enables the mapping of molecular dissociation and recombination as a function of longitude. By extending these retrievals using a novel technique to longitudinally resolved spectra, we aim to connect phase-dependent chemistry and thermal structure to atmospheric dynamics, and to critically assess whether the inferred elemental ratios support or challenge formation scenarios suggested by the NIRSpec analysis alone."

UNVEILING THE NATURE OF SUPER-PUFFS: EARLY RESULTS FROM A PANCHROMATIC JWST ATMOSPHERIC SPECTROSCOPY SURVEY

Michael Radica &
Caroline Piaulet-Ghorayeb, Dominic Samra, Luis Welbanks, Jacob Bean, Diana Powell, Michael Line, Peter Gao, Maria Steinrueck
University of Chicago, University of Chicago, Arizona State University, University of Chicago, University of Chicago, Arizona State University, Carnegie, University of Chicago

"With Neptune-like masses but Saturn-like radii, super-puff exoplanets present a fantastic opportunity for spectroscopic atmospheric characterization. With their abnormally large radii and incredibly low densities these planets have been likened to cotton candy, and present significant challenges to conventional models of planet formation. To unravel the origins of super-puffs, we are carrying out a 95 hr survey of the four most observable super-puff planets using JWST's NIRISS, NIRSpec, and MIRI instruments to construct panchromatic optical-to-MIR atmospheric spectra of these objects.
In this talk, I will give an overview of the initial results from this survey. The planets in our sample span a range of nearly 1000K in equilibrium temperature allowing us to study disequilibrium chemistry, cloud formation, and limb asymmetry at incredible signal-to-noise over a number of key temperature transitions. These spectra are some of the most precise that JWST will obtain over the entirety of its lifetime, and we will be able to robustly disentangle the impacts of hazes and internal heat on the inflated radii of the planets in this sub-population. We also unlock the full chemical inventory of these planets and obtain unprecedented insights into the natures of these most enigmatic of worlds."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE PANCHROMATIC TRANSMISSION SPECTRUM OF THE WARM JUPITER WASP-80 B

Anastasia Triantafillides &
Thomas Beatty
University of Wisconsin

Measuring the major carbon-, oxygen-, and hydrogen-bearing species for a growing population of gas giant exoplanets allows us to accurately estimate carbon-to-oxygen (C/O) ratios and metallicity (M/H) values, key diagnostics of planetary formation histories. When plotting existing measurements of C/O versus M/H there is a large scatter for the current population of transiting gas giant exoplanets with atmospheric measurements. However, it is unclear if this scatter is due to intrinsic or systematic analysis differences. Furthermore, very few planets have been observed in both transmission and emission within the same wavelength range by JWST. Measuring the atmosphere of both the dayside and terminators of a gas giant planet allows us to probe planet-wide atmospheric composition. Here we report a panchromatic transmission spectrum spanning 2.4—11 μm for the warm Jupiter exoplanet WASP-80 b (Teq = 820 K). We took spectroscopic observations with NIRCam's F322W2 and F444W filters as well as the MIRI LRS mode aboard JWST. We report detections of H2O, CO2, NH3, CH4 and CS2 in the atmosphere of WASP-80 b and compare the retrieved abundances to those from previously-published panchromatic emission spectra. The CH4 abundance is consistent with the abundance values from emission. However, abundances of H2O, CO2, and NH3 from the transmission spectrum are significantly higher compared to emission values. I will discuss why we think the difference between the transmission and emission abundances are most likely an artifact of different atmospheric modeling approaches, and I will argue that the apparent scatter in the present observed C/O vs. M/H diagram is likely dominated by similar systematic analysis artifacts.

RESULTS FROM TWO ULTRA-HOT JUPITER PROGRAMS WITH JWST/NIRSPEC: THE PHASE CURVE OF WASP-76B AND THE SECONDARY ECLIPSE OF KELT-20B

Joost Wardenier &
Thea Hood, Antoine-Darveau Bernier, Mark Hammond, Louis-Philippe Coulombe, Megan Weiner-Mansfield, Michael Radica, Pierre-Alexis Roy, Vivien Parmenier, Taylor Bell, John Allen, and many more!

University of Bern, Trottier Institute for Research on Exoplanets, University of Montreal (Canada), Côte d'Azur Observatory (France), University of Oxford (UK), University of Maryland (USA), University of Chicago (USA), UCLA (USA), Space Telescope Science Institute (USA), and many more!

"In this talk, I will present results from JWST/NIRSpec observations of the phase curve of WASP-76b (cycle 3) and the secondary eclipse of KELT-20b (cycle 4, data taken in October 2025). Both planets are ultra-hot Jupiters featuring a permanent dayside and a permanent nightside, making their atmospheric signals more challenging to interpret. WASP-76b and KELT-20b have been observed with a plethora of high-resolution spectrographs from the ground, and our JWST programs are uniquely poised to fill the gaps in our understanding of these benchmark exoplanets.

The aim of the WASP-76b phase-curve program is to obtain a detailed picture of the 3D temperature structure of the atmosphere, the heat-redistribution efficiency, east-west limb asymmetries, and the degree of molecular dissociation across the planet. I will show results from our search for asymmetric limb signals during transit, comparisons against predictions from global circulation models (GCMs), as well as phase-dependent temperature/abundance retrievals from the emission spectrum. A longer-term goal is to combine our JWST observations with data from ground-based spectrographs (e.g., ESPRESSO, IGRINS, NIRPS) to produce reliable volatile-to-refractory ratios that allow to probe the formation history of the WASP-76b.

Thanks to its favorable impact parameter and high equilibrium temperature, KELT-20b is one of the best eclipse-mapping targets. I will discuss our efforts to produce the most detailed temperature map of an exoplanet to date, based on its secondary-eclipse signal. With our 2D map of the dayside of KELT-20b in hand, we can put tight constraints on its hotspot offset as well as potential latitudinal asymmetries. Through comparisons to GCMs, we will be able to characterize the efficiency of heat redistribution and drag mechanisms at play in KELT-20b's atmosphere. Additionally, the observation produced a high-quality emission spectrum that allows us to measure the abundances of H2O and CO on the dayside of the planet.

In summary, our JWST programs provide a unique window into the atmospheric physics and chemistry of two canonical ultra-hot Jupiters."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

BEYOND A HOMOGENEOUS TERMINATOR: SPATIALLY AND TEMPORALLY RESOLVED JWST SPECTROSCOPY OF KEPLER-12 B

Måns Holmberg &
Nestor Espinoza, Diana Powell, Ryan MacDonald, Maria Steinrueck, Yanbo Pan, Anna Lueber, Dominic Samra, Carlos Gascon, Arjun Savel, Mercedes Lopez-Morales, Joao Manuel Mendonca

Space Telescope Science Institute, University of Chicago, University of St Andrews, University of Chicago, University of Michigan, University of Bern, University of Chicago, Space Telescope Science Institute, University of Maryland, Space Telescope Science Institute, University of Southampton

The unprecedented precision of JWST has opened a new frontier in exoplanet atmospheric characterisation, enabling transmission spectroscopy beyond the classical assumption of a homogeneous terminator. Here we present two JWST/NIRSpec transmission spectroscopy observations of the hot Jupiter Kepler-12 b that robustly resolve the planet's morning and evening limbs and, for the first time, reveal significant temporal variability between visits. We detect striking limb asymmetries, with the morning hemisphere being on average 770±100 K (>590 K, 2σ) cooler and substantially more aerosol-rich than the evening hemisphere, which shows no evidence for clouds. The inferred temperature contrast is markedly larger than previously reported for hot Jupiters, highlighting the diversity of atmospheric structure among giant exoplanets. We confidently detect H_2O, CO_2, and H_2S, and infer a subsolar atmospheric metallicity. Despite the pronounced thermal and aerosol asymmetries, we find no statistically significant differences in gas-phase abundances between the two limbs. In addition to spatial structure, we identify significant visit-to-visit differences that can be explained by changes in temperature and/or aerosol properties, with the strongest variability appearing on the evening limb. We further demonstrate that properly accounting for inter-wavelength and inter-limb covariance is essential for high-precision limb-resolved spectroscopy, yielding substantially improved constraints compared to traditional analyses. Together, these results demonstrate JWST's ability to directly probe the three-dimensional and time-variable thermal, aerosol, and chemical structure of giant exoplanet atmospheres, ushering in a new era of spatially and temporally resolved atmospheric characterisation.

exo 6

EXOPLANETS PORTO 2026

CONFERENCE ABSTRACTS E-BOOK

TUESDAY, JUNE 30

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

THE PLATO MISSION

Don Pollacco
University of Warwick

It's been nearly 20 years since PLATO was first proposed to ESA and now we are just a few months away from launch (20th January 2027) – it's been a long journey. PLATO will be sensitive to Earth-Sun analogs around nearby stars. In this talk I will summarise the mission and its science objectives along with its dedicated ground-based observation programme. I'll also give details of the mission data products and when they will be made public (the bulk of the data and associated photometric data products, becoming available within 3 months of the end of an observation). The PLATO mission consortium has always been, and will continue to be, open to members of the scientific community and we encourage researchers to get involved.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

A GALACTIC CENSUS OF EXOPLANETS FROM THE NANCY GRACE ROMAN SPACE TELESCOPE

Bernard Gaudi &
The Roman Galactic Exoplanet Survey Project Infrastructure Team
The Ohio State University

The Nancy Grace Roman Space Telescope (Roman) is NASA's next major astrophysics mission, scheduled for launch in late 2026. Roman will feature a wavelength range, aperture, and angular resolution comparable to the Hubble Space Telescope but with approximately 100 times the field of view and 1,000 times the sky-mapping speed. This capability allows it to survey large sky areas rapidly or repeatedly observe smaller areas with high frequency. A key community survey during Roman's primary mission will be the Roman Galactic Bulge Time Domain Survey (RGBTDS). This survey will monitor about 1.7 square degrees of the Galactic center with a cadence of approximately 12 minutes using a wide 1–2 micron filter, spanning six seasons of 72 days each, with a total survey duration of 440 days. The RGBTDS aims to detect thousands of cold bound and free-floating planets using microlensing, as well as about 100,000 hot and warm transiting planets. Roman's transit and microlensing data will enable the first comprehensive statistical survey of exoplanets within all the major stellar populations of the Galaxy, covering planets with radii or masses greater than twice that of Earth across all orbital distances. I will highlight Roman's capabilities and expected scientific yield, and describe the efforts of the Roman Galactic Exoplanet Survey Project Infrastructure Team (RGES-PIT), which is developing the framework, tools, and strategies to maximize the scientific return from the RGBTDS.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

EARLY OBSERVATION PLANS FOR THE NANCY GRACE ROMAN SPACE TELESCOPE CORONAGRAPH INSTRUMENT

Oscar Carrión-González &
on behalf of the Roman Coronagraph Instrument Community Participation Program (CPP)
MPIA

The Nancy Grace Roman Space Telescope is now expected to launch in fall 2026. It will carry on board a Coronagraph Instrument that will demonstrate key technologies for the Habitable Worlds Observatory. During the first 18 months of the mission, the Roman Coronagraph Instrument will perform high-contrast imaging observations with novel starlight suppression techniques and deformable mirror mechanisms that have not been tested in space before. The top requirement to be demonstrated is the capability of measuring, with a signal-to-noise ratio of at least 5, a point source object with contrast of 10^-7 in Band 1 (575 nm) located at 6 – 9 λ/D from a host star brighter than magnitude V=5. Time limited thermal vacuum (TVAC) demonstrations improved on this performance by at least a factor of 4. The sensitivity levels reached in the observation phase may thus provide the first direct-imaging observations of an exoplanet in reflected starlight. The Community Participation Program team (CPP), consisting of NASA and its international partners (CNES, ESA, JAXA, MPIA), is tasked with the design of the Coronagraph Instrument's observation phase. The goal of the CPP is to fulfil the technology-demonstration goals of the instrument while maximizing the long-term value of these observations –which will have no proprietary period– for the broader community. Through a white paper call in 2025, the CPP gathered inputs from the community, showcasing support for several key science cases and tech-demo activities. We will present the general results of this call for white papers, and will pinpoint the priorities identified by the CPP. From these, we will summarize the observations planned for the initial ~6 months of the Coronagraph Instrument on-sky observation phase.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

THE FUTURE OF PRECISION RADIAL VELOCITIES: FROM SMALL PLANET DETECTION TO PHYSICAL CHARACTERIZATION

René Doyon
Université de Montréal

"We are living through a golden age of terrestrial small-planet characterization. Space missions such as Kepler, TESS, and the upcoming PLATO mission are delivering an expanding sample of transiting transiting rocky planets including the emerging class of water worlds. JWST has opened a new era in the atmospheric characterization of these worlds, while future Extremely Large Telescopes will provide powerful new capabilities for probing their atmospheres, with the exciting prospect of detecting biosignatures on nearby rocky planets. Precision radial velocities (PRVs) remain the cornerstone technique for measuring the masses and bulk densities of transiting rocky planets, thereby linking planetary radii to interior structure models and atmospheric studies. Low-mass M dwarfs are particularly favorable targets, offering enhanced radial-velocity signals and deeper transits for Earth-sized planets.

In this presentation, I will discuss recent advances in PRV instrumentation and analysis techniques that are pushing the field toward the sub-meter-per-second regime. I will highlight key results from facilities such as ESPRESSO, NIRPS, and other state-of-the-art PRV instruments, with a particular focus on the detection and characterization of small planets orbiting M dwarfs. I will also examine the principal obstacles to further progress, including stellar activity, telluric contamination, detector sampling effects, detector noise and modal noise in fiber-fed spectrographs. Particular emphasis will be placed on emerging signal-processing approaches, including line-by-line analyses and machine learning techniques that are helping to unlock ever higher levels of precision.

Finally, I will briefly explore future prospects enabled by new infrared facilities such as HISPEC, iLocator, the NIRPS K-band extension, ESPRESSOred and ultimately ANDES on the ELT. Together, these developments are transforming precision radial velocities from a discovery tool into a cornerstone of the physical characterization of small worlds.

I will first revisit how fundamental principles of direct imaging (photon noise, diffraction) reveal which exoplanets and observables can be within reach of today and tomorrow's large telescope. The performance gap between these theoretical limits and current on-sky performance highlights significant engineering challenges as well as promising research opportunities. Among these, I will discuss two broad interconnected emerging research themes with particularly strong short-term opportunities as well as transformational long-term science potential:

First, advances in wavefront sensing (WFS) are essential for achieving both deeper raw contrast, and accurate PSF reconstruction. Wavefront sensors with improved sensitivity to low-order aberrations, and accurate recovery of the unwanted starlight in the focal plane are especially critical. WFS operating at the diffraction limit sensitivity are being developed, enabled by advances in optics and photonics, as well as new algorithms and numerical analysis capabilities. Active research activities include predictive control and focal-plane wavefront sensing.

Second, new optical approaches for starlight suppression and exoplanet spectroscopy are needed to simultaneously achieve high spectroscopy throughput and low contamination from unwanted starlight and background. I will show that there are fundamental differences and competing requirements between searching for exoplanet(s) with DI and acquiring their spectrum. Thanks to recent advances in astrophotonics, a system can be optimized for spectroscopy (if the exoplanet position is known) in ways that cannot be realized with conventional optics and coronagraphs, yielding a ~10x gain in observing efficiency and enabling recovery of exoplanet spectra at angular separations near the telescope diffraction limit.

These research themes are rapidly evolving, and are relevant to both space and ground systems. Their maturation and implementation will define the roles and complementarity between current and upcoming facilities for detailed characterization of low-m"

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

TIANLIN: A 6.6M UV-VIS-NIR SPACE TELESCOPE FOR THE EXPLORATION OF EXOPLANET AND BIOSIGNATURES

Wei Wang &
Meng Zhai 1, Gao Zhao 1, Jifeng Liu 1, Boqian Xu 2, Xuejun Zhang 2
National Astronomical Observatories, Chinese Academy of Sciences; 1. National Astronomical Observatories, Chinese Academy of Sciences 2.Changchun Institute of Optics,Fine Mechanics and Physics,Chinese Academy of Sciences

"The next decade will witness a dramatic expansion in the known population of small exoplanets, as missions such as TESS, PLATO, and China's upcoming ET mission are expected to reveal thousands of new transiting planets, including more than one hundred potentially habitable terrestrial worlds. Yet despite this rapid progress, no planned facility—ground or space—will be capable of obtaining the comprehensive atmospheric characterization or biosignature assessments required to address whether any nearby Earth-sized planets are truly habitable or inhabited.
To bridge this critical gap, China is currently supporting a concept study for Tianlin, a 6+ meter class space telescope covering the UV–NIR range, with operations envisioned to begin around 2035+ and a mission lifetime exceeding 10 years. Tianlin is designed with a primary science goal of directly characterizing rocky planets in the habitable zones of nearby stars, enabling the detection of key atmospheric species and potential biosignatures. Our preliminary simulations indicate that Tianlin would substantially advance the detection of O_2, O_3, CH_4, and other chemically significant species on a statistical sample of nearby terrestrial planets.
Beyond its exoplanet focus, Tianlin will also deliver transformative science in galaxy formation, nearby galaxy archaeology, and early-universe astrophysics, enabled by its wide wavelength coverage and large collecting area.
In this talk, we will present an overview of the Tianlin mission, including the baseline telescope and instrument requirements derived from our first-generation simulations. We will also discuss the mission's complementarity with international efforts such as HWO, LIFE, and Ariel, and highlight opportunities for global collaboration in hardware development, data processing, and scientific exploitation."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

RESOLVING THE INNER 1 AU OF Β PICTORIS: PLANETARY DYNAMICS AND CLOSE-IN DUST STRUCTURES WITH VLTI/GRAVITY+

Jonas Sauter
Max Planck Institute for Astronomy

The β Pictoris system is a young (~20 Myr) planetary system hosting two confirmed giant planets and a debris disk composed of a primary midplane and a misaligned secondary component. Using the GRAVITY+ interferometer at the VLTI, the only facility currently capable of resolving sub-AU scales in nearby young planetary systems, we spatially resolve the inner 1 AU of the system, enabling a direct measurement of the stellar obliquity and the detection of previously unresolved inner dust structures. We find that the stellar spin axis is aligned with the secondary disk component rather than the primary disk, suggesting a complex early dynamical history and providing new constraints on disk-driven migration scenarios. In addition, we detect a new inner disk at ~0.1 AU observed in scattered light. While its origin remains uncertain, possible explanations include exozodiacal dust replenished by material in mean-motion resonance with the known giant planets, or dust produced by the disruption or evaporation of large rocky bodies. Given the young age of the system, this inner dust component may trace ongoing terrestrial planet formation processes, offering a rare observational probe of rocky material evolution in the innermost regions of a young planetary system.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

EARTH-SIZED PLANETS AROUND THE SMALLEST STARS: OCCURRENCE RATES FROM SPECULOOS

Florian Lienhard &
Catriona Murray
ETH Zurich; University of Colorado Boulder

"Ultra-cool dwarfs (UCDs), stars with effective temperatures below 2700 K, are among the most numerous objects in the Galaxy, yet our understanding of their planetary populations is very limited. While the TRAPPIST-1 system demonstrated that these low mass hosts can support multiple terrestrial planets within their habitable zones, it is still unclear if such architectures are typical of the UCD population. In this talk, I present a new measurement of planet occurrence rates for late M dwarfs, using the complete observational dataset from the SPECULOOS project. This analysis provides a vital update to the statistical landscape of the smallest stars (Murray and Lienhard 2026, in prep).
Since 2018, the SPECULOOS network of robotic 1 metre telescopes has monitored the nearest UCDs with high cadence photometry. Our analysis incorporates the full seven-year data set, providing the most complete census of this stellar regime to date. We quantify the survey sensitivity through extensive injection-recovery tests. In this process, simulated planetary signals are placed into the raw light curves, followed by the application of data cleaning and automated transit search to determine completeness as a function of planet radius and orbital period. The occurrence rates are derived via Bayesian inference, with particular scrutiny given to how detection criteria and observational constraints influence the resulting statistics.
We leverage detections and non-detections to constrain the average number of planets with orbital periods below approximately 7 days. These planets represent the targets most amenable to atmospheric characterisation. I compare these findings to the demographics of earlier M dwarfs observed by Kepler and TESS, offering insights into how planet formation efficiency may change at the bottom of the main sequence. This work provides the statistical context necessary to guide efforts to identify habitable planets in the solar neighbourhood and informs our understanding of the broader Galactic population in the context of what we know about TRAPPIST-1."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

A STELLAR OBLIQUITY MEASUREMENT FOR THE DISINTEGRATING PLANET BD+05 4868 AB

Steven Giacalone &
Andrew Howard, Heather Knutson, Morgan Saidel, Luke Handley
California Institute of Technology; California Institute of Technology

"The discovery of thousands of transiting exoplanets has provided a fascinating window into planetary environments and characteristics unseen in the Solar System. Among the most exotic cases are disintegrating planets: close-in planets thought to have masses similar to and lower than that of Mercury under such intense irradiation from their host stars that they shed mass catastrophically, leaving comet-like tails of dust in their wakes. These tails sometimes occult several percent of the stellar surface and produce prominent signals, providing one-of-a-kind laboratories for studying small, rocky planets that would otherwise go undetected. Three disintegrating planets were discovered around faint (V > 15) stars in Kepler and K2 data and a fourth was recently found around a relatively bright (V = 10.16) star in TESS data. This newly discovered disintegrating planet, BD+05 4868 Ab, produces a deep (~1%) and consistent transit, providing the unprecedented opportunity to investigate the orbits and internal compositions of the smallest planets in the Galaxy.
We present the results of a coordinated follow-up effort to measure the stellar obliquity of BD+05 4868 A via the Rossiter-McLaughlin effect. We obtained simultaneous Keck/KPF radial velocities and CHEOPS photometry of several transits, enabling a precise measurement of the projected stellar obliquity. While our analysis is ongoing at the time of submission of this abstract, preliminary results suggest that the orbit of the planet is prograde and that the system is spin-orbit aligned, consistent with formation and migration in the inner protoplanetary disk.
Our result marks the first stellar obliquity measurement for a disintegrating planet and breaks the record for the lowest mass exoplanet with a precisely measured spin-orbit angle by a wide margin. By searching for and characterizing more of these systems, we can gain unique insight into the natures of objects analogous to Mercury, dwarf planets, and massive moons in the Solar System, opening the door to an entirely new realm of exoplanet science."

MAIN ROOM
30/06 14:00–14:15

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE MASS-METALLICITY RELATION FOR GIANT PLANETS – A REVISION AND NEW INTERPRETATION

Jonathan Fortney &
Yayaati Chachan
University of California, Santa Cruz; University of California, Santa Cruz

Using a sample size of 147 warm (<1000 K) transiting giant planets with well-measured masses and radii, and a significantly revised thermal evolution model, we constrain the bulk "metal content" for super-Neptunes to super-Jupiters. Our work reveals that the population's heavy element mass follows a relation that is best fit with Mcore=15 Earth masses and and the accretion of metal-rich gas with a Z=0.09 (while solar composition is Z=0.015), with significant astrophysical scatter. Giant planets have a composition that is "mostly metal" until a mass of ~50 MEarth. This is consistent with the core-accretion scenario but suggests major revisions to the classical picture. As planet mass increases, bulk metallicity mostly declines but plateaus for super-Jupiter's at ~7x solar (or 3.3x stellar) metallicity. This explicitly shows that giant planets continue to accrete material enriched in metals during the gas accretion phase. We interpret these results in the framework of a 1D disk model where migration and sublimation of pebbles across ice lines enriches the gas in metals, leading to metal-rich accretion. We discuss implications for atmospheric observations of transiting and directly imaged giant planet composition from spectra.

ORBITAL DECAY OF HOT NEPTUNES

Isobel Lockley
University of Warwick

I present results of our ongoing long-term orbital period decay program with NGTS, specifically looking at rare hot-Neptune planets, which reside in the Neptunian desert parameter space. The formation and evolution of planets within the Neptunian desert is a largely unanswered question. Recent studies have used theories, such as tidally-driven Roche lobe overflow (RLO), to explain the presence of Neptunian desert planets. In this scenario, the inward migration of a planets would generate significant orbital period decay. The predicted changes in period are measurable with transit observations spanning several years. For example, Hallatt & Millholland 2025 propose the theory of 'lossy' RLO and calculate a predicted decay rate of ~0.5 ms/yr for LTT-9779b and TOI-3261b. We have been collecting precise ephemeris measurements for Neptune desert targets with NGTS since 2019 and combining these with results from TESS photometry we are able to achieve upper limits to the migration rates of several hot Neptunes. We compare our results to the predictions and discuss the implications for formation and migration theories.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE FIRST POPULATION SYNTHESIS OF PLANETS IN BINARIES (S-TYPE)

Arianna Nigioni &
Dr. Julia Venturini
Observatoire de Genève

The number of planets orbiting binary stars is increasing dramatically thanks to TESS, follow-up by direct imaging, and astrometric surveys like Gaia. Understanding the origin and orbital architecture of these systems requires end-to-end planet formation models, meaning that they incorporate into one single framework different processes that act during planet formation. In the context of the PAIRS project, we have adapted the Bern Model of Planet Formation and Evolution (e.g., Emsenhuber et al. 2021) to the presence of a companion star (Venturini, Nigioni et al. 2026, Nigioni et al. 2026, accepted in A&A). This enables us, for the first time, to model the formation of planets around one of the two stars in the binary (S-type planets) within a global planet formation model. When this model is run thousands of times, with initial conditions drawn from observed distributions, it yields a synthetic planet population, enabling statistical comparisons with the observed S-type exoplanet population. In this talk I will present the results from the first synthetic S-type population. Among the results that I will present, I will emphasize three key findings that directly link our synthetic S-type population to current observational constraints. First, we find a strong suppression of giant planet occurrence in close binaries (binary separation < 100 au), in agreement with observations (Hirsh et al. 2021). Second, we find that planet occurrence peaks at a binary separation of ~250 au, consistent with observed trends in planet-hosting binaries (e.g., Thebault & Bonanni 2025). Third, our model predicts a marked suppression of mini-Neptunes in binaries tighter than 100 au, in line with the deficit reported by Sullivan et al. (2025) using Kepler data. Furthermore, for wide binaries (binary separation > 1000 au), the synthetic S-type population closely resembles that of single stars run with the same model, a feature again consistent with observations (Fontanive & Bardalez Gagliuffi 2021). Together, these results indicate that our global planet formation model naturally reproduces several key demographic features of planets in binaries, which PLATO, but also other future space and ground-based missions, will be able to test.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

WITNESSING GIANT PLANET FORMATION IN THE ACT

Charles Law &
Richard Teague, Romane Le Gal, Ilse Cleeves
MIT, IRAM, UVA

Giant planets observed at far orbital separations challenge the standard picture of core accretion, which operates most efficiently in the inner tens of au. Instead, gravitational instabilities (GI) in massive protoplanetary disks may be a rapid alternative for forming giant planets at large radii. However, direct observational evidence of protoplanets forming via this mechanism has been limited. Here, we present high-resolution ALMA observations of the mm dust and molecular gas in the massive, edge-on Gomez's Hamburger disk, which hosts a local over-density of more than ten Jupiter masses, known as GoHam B. The system's edge-on orientation enables a 3D reconstruction of the disk structure from the measured gas velocities and reveals key signatures of ongoing planet formation, namely: an asymmetric mm dust distribution and localized, one-sided sulfur monoxide (SO) emission tracing hot, dense gas near GoHam B. SO is known to be associated with highly-energetic processes, and its presence indicates that the gas around GoHam B is being locally heated due to ongoing gravitational collapse. Not only is this the first such collapsing protoplanetary fragment observationally discovered, but it also confirms longstanding GI-model predictions and provides us with a direct view of the earliest stages of wide-separation, giant planet formation at unprecedented spatial scales.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

CORE-LESS SUB-NEPTUNES AND IMPLICATIONS FOR THE MASS–RADIUS RELATION

Aaron Werlen &
Edward D. Young (1), Sarah P. Marcum (1), Lars Stixrude (1), Cornelis P. Dullemond (2)
(1) University of California, Los Angeles, (2) University of Heidelberg

"Sub-Neptunes dominate the exoplanet census and occupy a mass and radius regime distinct from terrestrial planets. Their larger masses imply substantially higher interior pressures and temperatures, yet their internal structures are commonly modeled as scaled-up terrestrial planets, consisting of a dense iron core, a silicate mantle, and a hydrogen-rich envelope. In this work, we test whether this layered picture remains physically valid under the extreme conditions expected in sub-Neptune interiors by using density functional theory molecular dynamics (DFT-MD) simulations and thermodynamic mixing models to examine how silicates, iron, and hydrogen interact deep inside these planets.

We find that sub-Neptunes containing hydrogen at the weight-percent level lack a distinct metal core once interior pressures exceed ~20 GPa and temperatures reach ~5000 K. Under these conditions, a separate metal phase is not thermodynamically stable and can only exist at lower pressures and temperatures, confining any compositional layering to relatively shallow regions of the planet. As a result, the deep interiors of typical sub-Neptunes are effectively core-less, consisting of supercritical mixtures of silicates, iron, and hydrogen rather than classically differentiated structures.

Incorporating this behavior into coupled interior–atmosphere structure models suppresses the formation of a dense, Earth-like iron core in hydrogen-bearing interiors, leading to lower bulk densities and larger planetary radii. For a representative 6 Earth-mass sub-Neptune containing 2 wt% hydrogen, we find that a fully mixed interior produces a transit radius roughly 10% larger than an otherwise identical planet with a discrete iron core, corresponding to density differences at the tens-of-percent level. These results imply that interior phase behavior, including the ability of hydrogen to participate chemically in the deep interior, fundamentally controls the internal structure of sub-Neptunes, with observable mass–radius trends emerging as a direct consequence."

INSIGHTS ON EXOPLANETARY COMPOSITIONS AND STRUCTURES FROM POLLUTED WHITE DWARFS

Isabella Trierweiler
Yale University

Polluted white dwarfs are unique probes of exoplanetary compositions. These stellar remnants are actively accreting debris from their planetary systems, providing direct measurements of the bulk elemental abundances of exoplanetary material. In this talk, I will discuss the implications of these abundances for the water content and core-mass fractions of exoplanetary bodies. I will show that many bodies appear to have significant excesses of oxygen, indicating a range of water contents similar to that of meteorites and moons in the solar system. I will similarly show that the inferred core-mass fractions of the accreted exoplanetary bodies span a large range but tend to be similar to that of the earth. Finally, I will demonstrate that variation in these exoplanetary core-mass fractions is so far consistent with predictions from galactic chemical evolution, and discuss the feasibility of measuring variations in exoplanet compositions across the galaxy.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE DIVERSITY OF COLD WORLDS: AGE AND CHARACTERIZATION OF THE EXOPLANET COCONUTS-2B

Rocio Kiman
University of California, Santa Barbara

Studying cold brown dwarfs (BD) is key to understanding the diverse characteristics of Jupiter-like atmospheres. COCONUTS-2, a wide binary system composed of a T9 object and an M3 star, presents a unique opportunity to study these cool objects. As part of a JWST program to study the coldest BDs, we obtained NIRSPEC G395H high resolution spectra and MIR F1000W, F1280W, and F1800W photometry for the T9 component, a 7.5 Mjup exoplanet. In this work, we performed a detailed analysis of the age of the system by studying the membership of the M3 star to moving groups. We found that the system is relatively young (414 Myr). In this talk, I will present our age analysis, the atmospheric composition of the secondary component obtained from the JWST spectra, and discuss the conclusion that COCONUTS-2b formed with the same mechanism as a star. I will also talk about the continuation of this work, using the new SPHEREx spectra to study the diversity of low-gravity giant planet analogs. This sample of benchmark objects will be key to study exoplanet spectra from JWST.

TRACING THE DYNAMICAL AND ATMOSPHERIC EVOLUTION OF THE YOUNG V1298 TAU PLANETARY SYSTEM

Hinna Shivkumar &
Sérgio Gomes, Jean-Michel Désert, John Lopez, Vatsal Panwar, Saugata Barat, Antonija Oklopčić, James Sikora, Thomas Wilson, Silvia Toonen

University of Amsterdam; University of Amsterdam, Leibniz-Institut für Astrophysik Potsdam (AIP), University of Amsterdam, University of Birmingham, Massachusetts Institute of Technology and University of Southern Queensland, University of Amsterdam, Lowell Observatory, University of Warwick, University of Amsterdam

The Galaxy's most common planetary systems consist of several Earth- to Neptune-sized planets on compact orbits, yet the young (10–30 Myr) star V1298 Tau hosts an unusual compact system of four large planets (≈5–10 Earth radii) arranged in a chain of near-mean-motion resonances that generate transit-timing variations of several hours. This system provides a rare opportunity to jointly investigate early dynamical and atmospheric evolution. We present new CHEOPS observations of the three innermost planets, delivering high-precision radius measurements that significantly improve constraints on their bulk densities and internal structures. Combined with recent mass estimates from transit-timing variations and atmospheric studies, we test whether the system formed in a resonant chain and subsequently evolved through tidal migration. We find that the planets are currently too far from exact commensurabilities for tidal dissipation alone to have driven them out of resonance, disfavouring a primordial full resonant chain. We find that the observed architecture produces only weak forced eccentricities compared to the reported values, implying past dynamical excitation. Accounting for post-formation planetary contraction further modulates the rate and direction of tidal migration, reducing the likelihood of resonance capture and suggesting formation with period ratios already below resonance. We place the dynamical history of this system in the context of atmospheric evolution using complementary Hubble and JWST observations, which reveal an extended hydrogen–rich atmosphere, with unexpectedly low metallicity for V1298 Tau b and a lack of methane, pointing to strong atmospheric mixing. Evolution models suggest substantial atmospheric loss over the next gigayear, potentially transforming the planet into a Neptune-sized world. V1298 Tau thus serves as a benchmark for interpreting atmospheric properties and future mass loss through the lens of early dynamical evolution, a synergy that will be greatly expanded by the large sample of young planets expected from ESA's forthcoming PLATO mission.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

EXPLORING ATMOSPHERIC ESCAPE FROM WATER-RICH SUB-NEPTUNES WITH FULL-ATMOSPHERE MODELS

Anna Ruth Taylor &
Tommi T. Koskinen1, Chenliang Huang (黄辰亮)2, Anthony Arfaux3, and Panayotis Lavvas4,5

University of Arizona, 1Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA 2Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China 3LIRA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université Paris Cité, Meudon, France 4Laboratoire Enviromnements et Atmosphères Terrestres et Planétaires, Université de Reims Champagne Ardenne, Reims, France 5Institut d'Astrophysique de Paris, UMR CNRS 7095, Paris, France.

Understanding atmospheric escape from sub-Neptunes is critical for constraining planet evolution and understanding the known planet population. Observations of escaping atmospheres increasingly use the He I 1083 nm triplet as a ground-accessible tracer of extended upper atmospheres, enabling direct comparisons across planets with diverse bulk densities and irradiation environments. However, helium detections and upper limits among sub-Neptunes are difficult to interpret: the metastable helium population depends sensitively on the temperature profile, ionization balance, and composition, so similar irradiation levels can produce very different excited He I signals. Helium-escape modeling has largely been shaped by hot-Jupiter applications, where H/He-only treatments are often sufficient. In sub-Neptunes, especially ones that are water-rich or metal-enriched, molecules and heavier species can survive to low pressures, motivating models that include molecular chemistry and lower-atmosphere coupling. In these atmospheres, H2O, H2, and associated molecular ions can alter heating/cooling, modify electron densities, and shield helium from ionization, directly changing the predicted He I 1083 nm transit depth. We present a full-atmosphere modeling framework to address this problem that links a 1D multi-species hydrodynamic escape code to a lower/middle atmosphere model and includes an expanded chemical network for sub-Neptunes with molecular hydrogen and water. Applying this framework to three benchmark sub-Neptunes spanning different bulk densities and irradiation levels, we predict their mass-loss rates, He I 1083 nm transit depths, and quantify how helium absorption is impacted by molecular chemistry. These results provide physically interpretable context for current and future near-IR helium surveys and demonstrate that water-rich chemistry can be essential for translating He I measurements and non-detections into constraints on mass loss, atmospheric composition, and evolutionary history.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

LIFTING THE COMPOSITION DEGENERACY OF SUB-NEPTUNES BY UNDERSTANDING THEIR MOLECULAR ESCAPE

Matthäus Schulik &
Tyger Peake, Archie Manley
Imperial College London; Queen Mary University London, Imperial College London

“Determining the composition of sub-Neptune atmospheres as a roadmap to understand their bulk composition is a field of intense current research. Hereby the frequent non-detections of the atmospheres of sub-Neptunes poses a roadblock as well as a puzzling issue. A way of circumventing this problem would be to instead detect the composition of atmospheric outflows, and map their chemistry to the chemistry of the planet. While escaping atomic species have been intermittently detected in the past, a new avenue lies so far unexplored – that of escaping molecules. Their many lines, taken together with a gentler stellar background might open up a new way of characterizing planets through their escaping atmospheres.
This however requires new, detailed models of atmospheric escape, which include reactive hydrodynamics. To this end, I will present new hydrodynamics simulations of hydrogen-rich and metal-rich atmospheres, yielding new molecular fingerprints of escaping gas. This is enabled by the recombination and rapid advection of outflowing molecules, spreading them over ~10 planetary radii, yielding a large observable surface for transits. Lastly, I will assess the detectability of specific lines in non-LTE states.”

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE GEOASTRONOMY OF SUB-NEPTUNES

Kevin Heng &
Steve Mojzsis, Fabrice Gaillard, Meng Tian, James Owen
Ludwig Maximilian University; Bayreuth, Orleans, LMU-Munich, Imperial College

One of the biggest surprises of exoplanet science is the discovery of the small exoplanet population between the sizes of Earth and Neptune. Super Earths appear to be scaled-up versions of rocky planets. However, it is less clear that sub-Neptunes are scaled-down versions of gas-giant planets, other than by analogy. The rocky cores and atmospheres of sub-Neptunes occupy comparable volumes (and thus have comparable extents in radius), but the cores dominate the mass budget if the atmospheres are hydrogen-dominated. Since the cores dominate the masses of sub-Neptunes, geochemical outgassing cannot be ignored. I will show that the temperature-pressure conditions at the surfaces of these cores exert a zeroth-order control on the atmospheric chemistry. Less massive (and smaller) sub-Neptunes have lower core surface pressures and temperatures, which leads to atmospheres with higher mean molecular weights. This naturally leads to a gradient in mean molecular weight across the radius valley of small exoplanets. The strength of this gradient is controlled by the oxygen fugacity of these cores and not by the elemental abundance of carbon. These results imply a need to shift one's mental framework away from the planet formation-driven approach of prioritising the carbon-to-oxygen ratio and "metallicity" and towards the more geoscience-oriented approach of understanding the oxidation states of rocky mantles via the oxygen fugacity. This research is part of the European Research Council (ERC) Synergy Grant awarded to Project Geoastronomy (PIs: Gaillard, Heng & Mozjsis).

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

SERIOUSLY, WHAT IS GOING ON WITH K2-18 B?

Matthew Nixon &
Luis Welbanks, Sagnick Mukherjee, Michael Line, Yoav Rotman
Arizona State University; Arizona State University

"The temperate sub-Neptune K2-18 b has emerged as a keystone target for our understanding of both the atmospheres and interiors of small exoplanets. Despite a substantial JWST observational campaign incorporating multiple instruments and covering a broad wavelength range, the nature of this planet is still heavily debated, with different studies reaching drastically different conclusions. Previous analyses have suggested that this planet may host a thin H/He-rich atmosphere atop a liquid water ocean, or that it may be a gas dwarf whose atmosphere is a product of interactions between hydrogen and a magma ocean, or that K2-18 b is a scaled-down, metal-enriched version of a gas giant planet.
Here, we present extensive modeling that seeks to uncover the reasons underlying these disparate interpretations. We discuss how atmospheric inferences for K2-18 b are highly sensitive to both data and model considerations, such as offsets between instruments and the treatment of clouds and hazes. We show that seemingly minor changes in the chosen modeling approach can result in dramatically different interpretations. We also discuss how the conclusions drawn about the atmosphere of K2-18 b have significant implications for the planet's interior structure. We summarise our current overall understanding of the atmosphere and interior of this planet, and present possible future directions to finally resolve the mysteries of this intriguing world."

A MATTER OF PERSPECTIVE: HOW MODEL CONSTRUCTION CHOICES CAN IMPACT INFERENCES FROM JWST OBSERVATIONS

Yoav Rotman &
Luis Welbanks, Michael Line
Arizona State University; Arizona State University

"For the first time, exoplanet science has passed from the data-limited regime to the model-limited regime; put more simply, our data is too good and models need to catch up. This issue has been exacerbated by the improved precision and wavelength range of JWST, which has produced incredible detections and inferences. However, this increased capability has also led to contradictory claims from the same observations, such as possible biosignatures and bulk atmospheric properties that challenge our understanding of planet formation. These problems often arise from differences in the model composition. Assumptions about the temperature structure, chemical equilibrium, and gaseous species in the model have all been shown to lead to vastly different inferences from the same JWST data. One recent example of this is HD 149026 b, a hot Saturn that was observed in emission with JWST NIRCam. Originally, the large CO2 absorption feature visible led to claims of a metallicity enrichment at >200x relative to solar composition, significantly challenging the mass-metallicity relationship expected from exoplanet formation mechanisms. A latter analysis revised the metallicity to ~30x solar, though a more recent re-analysis now claims a metallicity ~70x solar. With one dataset and three possible interpretations, it is difficult to know whether HD 149026 b is an outlier, whether our understanding of planet formation is simply wrong, or whether this is all an example of the need for more panchromatic coverage.
Here, we show that the contradictory inferences from HD 149026 b's emission spectrum arise primarily because of sensitivity to differences in the modeling methodologies applied. We demonstrate that, by combining multiple modeling methodologies, we are able to build a consistent picture of the atmosphere of HD 149026 b, reconciling the previously contradictory estimates of its metallicity. Additionally, we discuss the importance of multiple modeling regimes and possible pitfalls encountered when relying on only one methodology."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

TIME-DOMAIN ATMOSPHERIC RETRIEVAL FROM JWST SPECTROSCOPIC LIGHT CURVES

Divyansh Srivastava &
Professor Andrzej Niedzielski
Nicolaus Copernicus University

"Atmospheric retrievals aim to infer the thermal structure, chemical composition, and cloud/haze properties of exoplanet atmospheres. With JWST, we are now in an era where we should start considering the limitations of modelling assumptions and not just focus on photon noise. The planet's atmosphere marks its wavelength-dependent opacity on the transit depth. The resulting transmission spectrum is the wavelength dependence of the apparent transit depth. Atmospheric retrievals are commonly performed on such 1D transmission spectra obtained from fitting independent lightcurves in each wavelength bin so that it provides an estimate of the apparent transit depth in each bin. Such a reduction to obtain the transmission spectrum compresses the native time-wavelength data into summary statistics. As a result of this, spectro-temporal covariances are compressed (because of the shared systematics for all the wavelength channels). To overcome this issue, a light-curve retrieval framework is needed (such as the S-retrieval vs L-retrieval method; Yip et al. 2020; Changeat et al. 2024).

We present the development of a new time-domain retrieval pipeline that evaluates the likelihood directly on the native spectroscopic flux time series f(λ, t) rather than just on the reduced transmission spectra. This keeps the inference closer to the data and helps any time-related parameters (systematics, noise, etc.) to be propagated into the atmospheric posteriors. We focus on the three benchmark planets that span different regimes (hot saturn, sub-Neptune, etc.), WASP-39 b, GJ 1214 b, and K2-18 b using JWST transmission spectroscopy data. On these three benchmark planets, we compare our time-domain retrieval method against spectrum-only retrieval.

We report initial results that show that using the time-domain retrieval changes the constraint on the atmospheric composition and cloud properties. We also show how this method can be extended for the atmospheric inference of the wider JWST transmission spectroscopy sample of exoplanets."

ATMOSPHERIC RETRIEVALS IN THE JWST ERA: LESSONS FROM HD 209458 B

Avinash Verma &
Jayesh Goyal, Swaroop Avarsekar, Gaurav Shukla
School of Earth & Planetary Sciences, National Institute of Science Education and Research (NISER), Homi Bhabha National Institute (HBNI), Jatni, Khordha752050, Odisha, India

"Over the past few decades, more than 6000 exoplanets have been discovered, shifting the focus from detection to understanding their physical and chemical properties, including atmospheric composition, temperature structure, and clouds. With the launch of JWST, we are now obtaining unprecedented observations of exoplanet atmospheres, offering high signal-to-noise ratios and broad wavelength coverage. However, interpreting these observations requires robust and physically realistic atmospheric models.
In this talk, I will present SANSAR (Suite of Adaptable plaNetary atmoSphere model And Retrieval), a flexible planetary atmosphere modeling and retrieval framework. SANSAR is a modular, Python based framework designed to plan and interpret observations of diverse planetary atmospheres, including Earth.
I will demonstrate the application of SANSAR using HST and JWST transmission spectroscopy observations of HD 209458 b, the first exoplanet with a detected atmosphere. Despite extensive observations, many of its atmospheric properties remain debated. Using SANSAR, we perform a comprehensive analysis of HD 209458 b using free, equilibrium, and self-consistent grid retrievals. We obtain the most robust constraints to date on its atmospheric composition, published in Verma et al. (2025). While free chemistry retrievals favor a highly sub-solar metallicity, both equilibrium chemistry and grid based retrievals are consistent with solar values. We examined the origins of these contrasting constraints reported in the literature, focusing on differences in model assumptions and the wavelength coverage adopted in various studies. We demonstrate that adopting a model in which C/O is varied by changing C/H can lead to markedly different conclusions compared to a model where C/O is varied by changing O/H, particularly when the analysis is restricted to a shorter wavelength range.
We find that JWST NIRCam observations alone can lead to an overestimation of molecular abundances. As previously noted, optical observations are crucial for establishing the spectral baseline, which in turn strongly constrains the retrieved water abundance. We therefore performed retrievals using three different data combinations: NIRCam only, NIRCam + WFC3, and STIS + WFC3 + NIRCam. This allowed us to isolate the contribution of each wavelength regime and quantify its impact on the final retrieved spectrum and inferred atmospheric properties. This highlights the need to combine JWST data with UV and optical observations from other facilities to obtain reliable constraints on abundances, carbon-to-oxygen ratios, and metallicity. In addition, we analyze the impact of different opacity treatment approaches commonly used in the community, on the interpretation of transmission spectra from modern telescopes.
These results have important implications for exoplanet atmosphere characterization with JWST and future missions such as ARIEL and ExoWorld."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

WHEN THE LIKELIHOOD LIES: RETHINKING EXOPLANET ATMOSPHERIC RETRIEVALS THROUGH STATISTICAL LEARNING

Emily Omaya Garvin &
Jason Bruederlin, Francesco Freni, Timothy Gebhard, Sascha P. Quanz
ETH Zurich, Independent researcher (Formerly ETH Zurich), University of Copenhagen, Independent researcher (Formerly MPI and ETH Zurich), ETH Zurich

"The rapid growth of exoplanet discoveries and new observatories has increased the need for robust atmospheric characterisation. These analyses rely on Bayesian retrievals comparing observed spectra to physically motivated models. Model complexity, however, yields intractable likelihoods, motivating approximate Bayesian computation (ABC) with Nested Sampling or MCMC. Such approaches can suffer from slow convergence and over-confident posteriors, mostly due to misspecified likelihood assumptions rather than sampling inefficiencies. While retrieval frameworks typically assume independent Gaussian noise, real spectroscopic data commonly exhibit wavelength-correlated and non-Gaussian noise from instrumental systematics, stellar residuals, rebinning, and modelling errors, biasing inferred parameters and uncertainties. Therefore, we aim to investigate the impact of correcting likelihood assumptions in atmospheric retrievals by explicitly accounting for correlated and/or non-Gaussian noise. For Gaussian correlated noise, we review existing approaches and introduce alternative (semi-)parametric methods to learn noise structures. For predominantly non-Gaussian regimes, we propose a novel approximate Bayesian framework that replaces the standard likelihood with a generalised statistical metric.

Our approach is twofold. (i) For Gaussian but wavelength-correlated noise, we estimate covariance matrices using statistical learning methods such as Mixed Models and Generalised Mixed Models, providing competitive alternatives to Gaussian Processes with an accessible application recipe. (ii) For non-Gaussian noise regimes, we replace the likelihood by a learned minimum-distance metric, derived using a Siamese Neural Network (SNN). The SNN embeds high-dimensional spectra into a low-dimensional space and learns an optimal distance, enabling robust spectral matching and parameter inference without assuming a specific noise model.

We test our methods on emission spectra from self-consistent libraries (Hot Jupiters: GOYAL2020; Earth-like planets: PyATMOS) and forward models under diverse noise conditions. Results show that learned covariance matrices improve retrieval accuracy, reduce parameter bias, and yield posteriors that consistently cover the true values at no additional computational cost. In non-Gaussian regimes, the SNN-based metric achieves up to 95% discriminatory performance in spectral matching, outperforming traditional likelihood-based methods. Compared to recent simulation-based inference techniques, our approach can require fewer simulations or training data while enabling cross-model comparisons and insight into residual-space topology.

We offer new solutions to restrictive data assumptions in atmospheric retrievals without compromising model selection. We discuss computational performance, convergence, scalability to higher spectral resolutions, and relevance for current and future observations with VLT, JWST, and ELT instruments."

USING OBSERVATIONS OF ESCAPING H/HE TO CONSTRAIN THE ATMOSPHERIC COMPOSITION OF SUB-NEPTUNES

James Rogers &
James Owen, Ethan Schreyer, James Kirk
University of Cambridge; Imperial College London, UCSC

The internal composition of sub-Neptunes remains a prominent unresolved question in exoplanetary science. In this talk, I will discuss a new technique to place constraints on envelope mean molecular weight that utilises observations of escaping hydrogen or helium exospheres. We apply this technique to archetypal sub-Neptunes, namely GJ-436 b, TOI-776 b and TOI-776 c, which have all been observed to be losing significant hydrogen content as well as relatively featureless transit spectra when observed with JWST. Combining constraints from atmospheric escape and transit spectroscopy in the case of TOI-776 c allows us to tentatively rule out the high mean molecular weight scenario, pointing towards a low mean molecular weight atmosphere with high-altitude aerosols muting spectral features in the infra-red. Finally, we reframe our analysis to the hycean candidate K2-18 b, which has also been shown to host a tentative escaping hydrogen exosphere. If such a detection is robust, we infer a hydrogen-rich envelope mass fraction of ~3%, which is inconsistent with the hycean scenario at the ~4 sigma level.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

GROUND-BASED ATMOSPHERIC CHARACTERIZATION OF VOLCANIC SUPER-EARTH L 98-59 D AT HIGH SPECTRAL RESOLUTION

Connor Cheverall
Universidad Diego Portales, Chile

Atmospheric characterisation of exoplanets using ground-based high-resolution transmission spectroscopy has traditionally focussed on large and close-in planets, such as hot Jupiters. In this work, we aim to extend this technique to smaller and more temperate planets by studying the atmospheric composition of the temperate super-Earth planet L 98-59 d (~1.5 R⊕; ~1.9 M⊕). Using high-resolution transmission spectra obtained using IGRINS on the Gemini-South telescope, we demonstrate the feasibility for atmospheric characterization of super-Earths using ground-based facilities, and confirm the previous tentative JWST inference of hydrogen sulfide (H2S) in the atmosphere of L 98-59 d at ≲3.9☐ (☐ ~ 390). This is the first ground-based inference of a molecular species in the atmosphere of a super-Earth planet, and reveals the sensitivity of spectrographs on 8m-class telescopes to the atmospheric characterization of such planets. By exploring a grid of atmospheric models, we find that the data favors a cloud-free atmosphere with an abundance of H2S corresponding to ~1–10× solar metallicity. We additionally place constraints on the atmospheric abundances of other molecular species. Assuming cloud-free models, super-solar abundances for CH4 and NH3 are ruled out at 3.6☐ and 4.6☐, respectively. Our constraints on the atmospheric composition are consistent with previous suggestions that L 98-59 d is a super-Earth with possible disequilibrium production of H2S driven by active volcanic outgassing from the surface. Future studies combining multiple observations with different facilities may be able to further constrain the atmospheric composition of this planet. This work underscores the promise of atmospheric characterization of super-Earth exoplanets using high-resolution spectroscopy with ground-based facilities.

IS THE HOT NEPTUNE DESERT POPULATED BY EXPOSED GIANT PLANET INTERIORS? REVEALING THE FIRST THERMAL EMISSION SPECTRA OF HOT AND SUPER-DENSE SUB-NEPTUNES

Pierre-Alexis Roy &
Björn Benneke, Louis-Philippe Coulombe, Michael Radica
UCLA; UCLA, IREx, University of Chicago

The growing number of discovered hot and super-dense sub-Neptunes, found in the hot Neptune desert, offers us an unprecedented opportunity: that of probing the potential exposed interiors of giant planets. Indeed, it is difficult to explain how such massive planets (20-70 Earth masses) can avoid triggering runaway gas accretion and remain small (2-4 Earth radii), with large bulk densities, and with hydrogen mass fractions of at most ~1%. Their large masses also make them mostly resilient to photoevaporation, meaning that either they formed like gas giants but subsequently lost their extended hydrogen envelope through energetic events such as giant impacts, or they formed later in the lifetime of the protoplanetary disk, when most of the gas had dissipated. The hot and over-dense planets TOI-824b and TOI-849b represent the best targets to tackle these questions, thanks to their high emission spectroscopy metrics. In this talk, we present the very first thermal emission spectra of the hot and dense desert dwellers TOI-824b and TOI-849b using JWST NIRSpec/G395M eclipse observations. Analyses of the planets' 2.7-5.2 μm emission spectra show hot day-side temperatures, consistent with highly inefficient heat redistribution (f=2/3), and deep CO2 absorption features, especially in the case of TOI-849b. These discoveries are direct signs of metal-enriched envelopes, supporting the eroded gas giant scenario and offering the first spectroscopic evidence that the hot Neptune desert may be populated by the exposed remnants of giant planets.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE 3D CLIMATE OF WASP-121B PROBED WITH HIGH-RESOLUTION SPECTROSCOPY

Adam Langeveld &
Emily Deibert, Ray Jayawardhana
Johns Hopkins University,University of Waterloo, California Institute of Technology

Ultra-hot Jupiters (UHJs) are strongly irradiated by their host stars leading to exotic atmospheres composed of a diverse array of atomic and ionic chemical species which undergo strong atmospheric flow from their permanent daysides to cooler nightsides. Evidence of such extreme chemical and dynamical processes can be directly measured from individual spectral lines resolved at high-resolution. Here I will present and discuss recent results from the SPECTRE-GHOST survey at Gemini South, which aims to use both high-resolution transmission and emission spectroscopy to perform a homogeneous survey of the daysides and terminator regions of ten UHJs to answer unique population-level questions on exoplanetary atmospheres. We compiled a chemical inventory of the terminator and dayside atmosphere of WASP-121b with detections in both its transmission and emission spectrum. Spectral features from many species were able to be "time-resolved", providing a measurable signal at multiple phases throughout the orbit. Through this, we measured changes in the spectral line strengths and Doppler shifts through time, including isolating the signal originating from the morning and evening terminator limbs separately, thus probing different planetary longitudes as the tidally-locked planet rotates during its orbit. These results demonstrate GHOST's ability to probe the 3D nature of UHJ atmospheres and provide valuable context for comparative studies to investigate atmospheric trends across a broad population of UHJs, especially as we prepare to harness the full power of the Extremely Large Telescopes in the coming 5-10 years.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

DIVERSITY IN THE ATMOSPHERES OF PLANETS NEAR THE RADIUS VALLEY

Björn Benneke &
the JWST Water-World & Sub-Neptune Survey Team
UCLA

One of the most fundamental results of the study of exoplanets has been the discovery that small planets are extremely abundant in the Universe and that they are seemingly divided into two distinct populations: rocky planets and sub-Neptunes with hydrogen-rich envelopes. Our recent JWST observations from two large-scale surveys however indicate that this division into two categories is not the full picture. By observing transmission spectra of 7 planets near the radius valley with JWST in great detail, and combining the data will other public results, we find an intrinsic diversity in the atmospheres near the radius valley. In this talk, we will discuss the main results and trends found in this meta study and, as part of this, we also present new JWST transmission spectra from multiple planets near the radius valley. We discuss implications on the formation, evolution, and volatile delivery of planets near the radius valley.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

A THICK ATMOSPHERE ON THE ULTRA-SHORT PERIOD LAVA WORLD HD 3167 B

Brandon Coy &
Megan Weiner Mansfield (1), Edwin Kite (2), Jason Eastman (3), Cole Smith (1), Anjali Piette (4), Eliza Kempton (2), Michael Zhang (2), Qiao Xue (2), Jacob Bean (2), Xuan Ji (2)

University of Chicago, (1) University of Maryland, (2) University of Chicago, (3) Center for Astrophysics, (4) University of Birmingham

"Thermal emission observations from JWST have revealed that most warm rocky exoplanets orbiting small M stars lack thick atmospheres. In stark contrast, there is growing evidence for atmospheres on 'lava worlds'— small (smaller than ~2 Earth radii) planets with dayside temperatures hot enough to completely melt their rocky dayside surfaces. The current data point to a bifurcation in Earth-sized rocky planets with and without atmospheres, but the cause of this apparent transition from 'bare rock' surface to a thick atmosphere occurs is uncertain. Despite both being lava worlds, GJ 367 b (sub-stellar temperature 1950 K) lacks a thick atmosphere, while observations of TOI-431 b (sub-stellar temperature 2600 K) and hotter planets suggest the presence of thick atmospheres.

We present a JWST MIRI LRS secondary eclipse observation of the ultra-short period lava world HD 3167 b (sub-stellar temperature 2450 K) that can help bridge this gap. HD 3167 b resides in a multi-planet system with 3 sub-Neptunes on short orbits; Rossiter-McLaughlin data and dynamical modeling suggest that planet c and d are on nearly polar orbits, whereas b orbits in the star's equatorial planet, leading to complex dynamical interactions between the planets. The HD 3167 system thus represents a natural test bed for the effects of dynamical planet-planet interactions and tidal heating on atmospheric retention. We show that the planet's white light eclipse depth is highly inconsistent with that expected of a dark, bare rock, suggesting the presence of a thick atmosphere. As this atmosphere could correspond to primordial volatiles or silicate vapor, follow-up observations are motivated to further investigate its atmospheric composition. HD 3167 b represents the coldest rocky USP with a detected atmosphere."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

SEARCHING FOR HOT WATER WORLD CANDIDATES WITH CHEOPS

Jo Ann Egger &
D. Kubyshkina, Y. Alibert, H. P. Osborn, A. Bonfanti, T. G. Wilson, A. Brandeker, M. N. Günther, M. Lendl, D. Kitzmann, L. Fossati, C. Mordasini, S. G. Sousa, V. Adibekyan, M. Fridlund, C. Pezzotti, D. Gandolfi, S. Ulmer-Moll, and the CHEOPS science team
European Space Agency (ESA/ESTEC)

"Studying the composition of exoplanets is one of the most promising approaches to observationally constrain planet formation and evolution processes. However, especially for small exoplanets, a wide range of compositions are compatible with their observed bulk properties, which complicates this endeavour. For planets close to their host star, part of this intrinsic degeneracy is naturally lifted without any additional observations. Since they receive a high level of high-energy irradiation, we expect at least part of their atmospheres to be evaporated, an effect that is especially important in the case of H/He atmospheres because of their low mean molecular weight.
In this context, we identify regions in mass–radius space where close-in planets must host atmospheres containing volatiles heavier than pure H/He. Since water is the most abundant of these volatiles, such planets are promising candidates for so-called water worlds. As only few currently known planets fall into these regions, we introduce a CHEOPS GTO programme aimed at identifying more of these potential hot water worlds.
Here, we present CHEOPS observations of the programme's first targets, TOI-238 b and TOI-1685 b. Using their precisely measured radii and masses, we examine their locations relative to the hot water world regime and explore the implications for their internal structures and atmospheric evolution. We show that TOI-238 b is a strong candidate for a hot water world, while TOI-1685 b remains consistent with either a volatile-rich composition or a bare rocky core, which is in agreement with more recent JWST observations of the latter planet."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE SUBSTELLAR RADIUS PROBLEM: DIRECTLY IMAGED PLANETS ARE MORE MASSIVE THAN WE THINK

Thomas Beatty
University of Wisconsin

"Brown dwarfs and high-mass giant planets occupy a critical region of parameter space bridging stellar and planetary regimes, serving as fundamental benchmarks for the evolutionary and atmospheric models applied to characterize directly imaged exoplanets. Accurate mass and radius determinations for these objects are essential for understanding their formation pathways and for interpreting the demographics of wide-separation companions revealed by high-contrast imaging surveys.

I will present an analysis of 17 transiting brown dwarfs with well-constrained masses, radii, and ages, excluding highly irradiated systems where external heating can complicate comparisons to theoretical predictions. Comparing measured radii to predictions from leading evolutionary models, I will show that all models systematically under-predict radii by 10-20%, with the discrepancy increasing for larger objects. This inflation shows no correlation with irradiation, tidal heating, or metallicity, suggesting an intrinsic deficiency in evolutionary models rather than environmental effects. The magnitude of the radius inflation mirrors the radius inflation problem in fully convective M-dwarf binaries, pointing toward a continuous issue across the hydrogen-burning boundary. This radius inflation also largely resolves the substellar luminosity problem identified by Dupuy et al. over a decade ago, who found that benchmark brown dwarfs are 0.2-0.4 dex over-luminous compared to model predictions; a 10-20% radius correction accounts for 50-80% of this discrepancy.

I will discuss the significant implications for directly imaged exoplanet masses. For these objects, masses are derived by combining spectroscopic surface gravities with model-predicted radii. If the true radii of these planets also exceed predictions by 10-15%, their masses are underestimated by 20-30%. This correction would shift many DI planets toward or across key thresholds: objects at 8-10 MJ would become 10-13 MJ, while those near 11-12 MJ would exceed the deuterium-burning limit.

I will explore how this mass revision would impose consequences on formation theory. The wide-separation giant planet population from GPIES and SHINE has been interpreted as favoring core accretion, based on a bottom-heavy mass function and correlation with stellar mass. However, core accretion faces a mass ceiling near 10 MJ from gap-opening feedback. If the true masses are 25% higher, more companions exceed this threshold, strengthening the case for gravitational instability.

Finally, I will discuss implications for the proposed planet-brown dwarf boundary from Schlaufman (2018) and note that JWST eclipse spectroscopy of transiting brown dwarfs would provide independent temperature constraints to further test evolutionary models."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

TWO STARS RISING: DEMOGRAPHICS, FORMATION AND CHARACTERISATION OF PLANETS ORBITING BINARY STARS

Julia Venturini &
A. Nigioni, M.P. Ronco, N. Jungo, A. Emsenhuber
University of Geneva

"Binary stars are ubiquitous, and planets within them are no longer rare: recent surveys suggest that ~20% of exoplanets reside in multiple-star systems (e.g Thebault & Bonanni, 2025). The number of detected planets orbiting binary stars has sharply increased over the past five years, mainly thanks to Gaia and direct imaging surveys, which resolve stellar companions in systems known to host planets. The number of planets in binaries is expected to keep rising steadily with the advent of Gaia DR4 and PLATO. Yet, despite rapid observational progress, how planets form and survive in dynamically perturbed binary environments remains an open question.

In this talk, I will begin by synthesising our current understanding of planets in binary systems, emphasising their role as unique laboratories for planet formation. While binaries provide dynamically challenging environments, they also isolate specific regions of the protoplanetary disc where planets assemble, potentially producing observable chemical signatures.

I then discuss recent demographic trends that hint towards a detrimental effect on planet formation for close binaries (binary separations < 100 au), and I will confront these trends with results from the first global planet formation model for S-type planets that we developed in the context of the PAIRS project (Venturini et al. 2026 and Nigioni et al. 2026, accepted in A&A). Our model includes the effects of tidal heating and disc truncation, irradiation from the companion star, and the gravitational perturbation induced by the stellar companion. Our results reproduce the observed demographic trends, and provide new constraints on where planet formation can proceed in binary environments. At the same time, our results indicate that explaining the formation of planets in extremely tight binaries, like Gamma-Cephei, remains challenging.

Finally, I will close by highlighting ongoing observational efforts that we are carrying out with CHEOPS and NIRPS to characterise planets in binaries, and the preparation work for PLATO on the same topic via the recently approved PLATO S-type planets Working Group."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

OCCURRENCE RATES OF CLOSE-IN PLANETS AND THE NEPTUNIAN DESERT ACROSS STELLAR TYPES FROM TESS

Kaiming Cui &
David J. Armstrong, Andreas Hadjigeorghiou, Marina Lafarga, Vedad Kunovac, Lauren Doyle, Luis Agustín Nieto, Rodrigo F. Díaz
University of Warwick; Instituto de Ciencias Físicas (CONICET / ECyT-UNSAM); Gerencia de Tecnología de la información y de las Comunicaciones (GTIC); Instituto Tecnológico de Buenos Aires (ITBA)

“Understanding the demographics of close-in exoplanets is essential for constraining models of planet formation and atmospheric evolution. We recently measured occurrence rates of close-in (0.5–16 d) planets with radii 2–20 R_earth around FGK main-sequence stars using four years of TESS SPOC FFI data cross-matched with Gaia and analyzed with a uniform detection, vetting, and validation pipeline. Applying a hierarchical Bayesian framework, we inferred occurrence rates in the two-dimensional period–radius plane using 10×10 bins, achieving substantially improved statistical precision compared to previous Kepler-based studies.
We find an overall occurrence rate of $9.4^{+0.7}{-0.6}%$, with posterior distributions consistent with Kepler results but with an order-of-magnitude smaller uncertainties under identical binning. The hot Jupiter occurrence rate is measured to be $0.39^{+0.03}{-0.02}%$, consistent within $1sigma$ with prior FGK estimates. Within the Neptunian desert region, we first measure a low overall occurrence rate of $0.08pm0.01%$, yielding a hot Jupiter to Neptunian desert occurrence rate ratio of 5:1. This ratio aligns with theoretical predictions that attribute the scarcity of Neptunian desert planets to the tidal evolution of hot Jupiters.
Building on these newly published results, we present new results focusing on a detailed characterization of the Neptunian desert across different stellar types. We quantify how the desert boundaries in period–radius space vary with host star mass and effective temperature, and model the underlying planet population using parametric and hierarchical approaches. We further investigate correlations with stellar metallicity to assess the role of formation efficiency versus post-formation atmospheric loss in shaping the desert. These results provide new empirical constraints on competing physical mechanisms responsible for the origin of the Neptunian desert and its dependence on stellar environment.”

TI-DYE: TESS INVESTIGATION – DEMOGRAPHICS OF YOUNG EXOPLANETS

Madyson Barber &
Andrew W. Mann; Andrew Vanderburg
University of North Carolina at Chapel Hill; University of North Carolina at Chapel Hill; Center for Astrophysics Harvard & Smithsonian

Young planets (<50 Myr) provide strong tests of planet formation and evolution theories by allowing us to observe sculpting processes in situ. However, differentiating between models has been limited by the small population of known young transiting planets. To address this, the TESS Investigation – Demographics of Young Exoplanets (TI-DYE) survey utilizes advancements in TESS light-curve reduction and updated young stellar cluster lists to significantly expand the census of planets in this critical age range. Our discoveries include additional planets in previously known systems (e.g., HIP 67522 c; 17 Myr) and an expansion of the lower age limit for transit detection (IRAS 04125+2902 b; 3 Myr). Many more discoveries are expected as we search for planets in the Orion, Vela, Sco-Cen, and Taurus-Auriga regions. With this expanded sample, we can compare the occurrence rates of young versus mature planets to determine which mechanisms dominate the formation of close-orbiting sub-Neptunes.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

SPIN-ORBIT ALIGNMENT OF PLANETARY SYSTEMS THROUGH SPACE AND TIME

Lauren Biddle
Princeton University

Exoplanets are organized in a broad array of orbital configurations that reflect their formation alongside Gyrs of cumulative dynamical history. This history is encoded in the star's spin-orbit "obliquity"—the angle between a star's rotational angular momentum vector and the orbital angular momentum vector of its planets—which is important for understanding the origin of the architectural diversity of exoplanets. Hundreds of obliquities have been measured for transiting planet systems, many of which have revealed planets on misaligned orbits. A question remains as to whether the primary origin of the obliquity distribution of exoplanet host stars is primordial (inherited from the protoplanetary disk) or generated by post-formation dynamical processes. I will present an analysis of the obliquities of 49 young, isolated Sun-like stars and their planet-forming disks, place them into context among systems with debris disks and transiting giant exoplanets, and discuss resulting insights about the evolution of spin-orbit (mis)alignment of planetary systems.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

EXOPLANET OCCURRENCE AND DYNAMICS IN A GALACTIC CONTEXT

Sarah Ballard
University of Florida

We present an investigation of planet occurrence and orbital dynamics as a function of galactic kinematic history. The canonical story of planet formation envisions a localized, isolated process, largely independent of galactic-scale phenomena. In this historical view, the primary role of the Galaxy in exoplanetary astronomy is the gradual enrichment of the interstellar medium with metals. Recent observational results, however, challenge the idea that initial conditions alone—metallicity, age, and local birth environment—are sufficient to explain the observed diversity in planet occurrence across the Galaxy. These new insights have been catalyzed by the Gaia mission, which enables the reconstruction of stellar trajectories and full kinematic histories throughout the Milky Way. By placing stars in motion, Gaia allows us to investigate the planetary census in the context of where stars have been, not just where they are. Controlling for metallicity and age, we discuss evidence for the galactic kinematic fingerprint upon planetary systems, employing the action-angle coordinates framework imported from Galactic astronomy.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

UNMASKING THE GIANTS: THE HUNT FOR GAIA SUBSTELLAR CANDIDATES WITH HARPS-N

Domenico Barbato
INAF – Osservatorio Astronomico di Padova

"The occurrence rate of planetary systems resembling the mass and separation hierarchy of our Solar System is a central question in exoplanetology. However, observational efforts to determine these occurrence rates have yielded conflicting results, often due to limitations in detecting and characterizing outer companions such as the mass degeneracy intrinsic to the radial velocity method. While the release of astrometric candidates from Gaia DR3 represents a key asset in solving RV mass degeneracy, astrophysical false positives among such candidates still undermine the full exploitation of astrometric measurements.
In this talk we present the first results of an ongoing follow-up HARPS-N campaign focusing on a selected sample of stars hosting in the outer regions either a known massive companion with astrometry-derived true mass or a Gaia DR3 astrometric candidate. We identify binary stars masquerading as substellar companions and the first confirmation of astrometric candidates in the sample, and the next steps towards an improved determination of ordered system occurrence rates."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

HOT JUPITERS, OBLIQUITY DAMPING, AND RESONANCE LOCKING

John Zanazzi
Pennsylvania State University

High-eccentricity migration predicts that hot Jupiters form with orbital planes misaligned with the host star's equator. Although hot host stars frequently have large stellar obliquities, cool hosts are predominantly aligned. Previous work postulates that damping from tidal flows interacting with the convective eddies of cool stars is strong, which aligns the stellar spin with the planet's orbit normal. However, these theories have proven problematic. We discuss how resonance locking – the coupling of the planet's orbit to a stellar gravity mode (g-mode) – can preferentially damp the obliquities of cool stars. The radiative cores of cool stars support internal gravity waves that drive strong tidal dissipation and damp obliquities. Hot stars lack radiative cores, and remain misaligned. Tidal theories are explained with simple, physical interpretations. Current avenues of investigation involving more efficient locks for metal-poor hosts, and non-linear dissipation, are discussed.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

PLANETS ACROSS SPACE AND TIME (PAST). VI. AGE DEPENDENCE OF THE OCCURRENCE AND ARCHITECTURE OF ULTRA-SHORT-PERIOD PLANET SYSTEMS

Peiwei Tu &
Jiwei Xie, Dichang Chen, Jilin Zhou
Nanjing University

Ultra-short-period (USP) planets, with orbital periods shorter than one day, represent a unique class of exoplanets whose origin remains puzzling. Determining their age distribution and temporal evolution is vital for uncovering their formation and evolutionary pathways. Using a sample of over a thousand short-period planets around Sun-like stars and kinematic methods from the Planets Across Space and Time (PAST) project, we find that the host stars of USP planets are relatively older than other short planets. Subsequently, we find that the occurrence of USP planets increases with time. Furthermore, we uncover evidence indicating that USP planetary system architectures evolve on Gyr timescales, as evidenced by the period distribution, orbital spacing, and transiting planet multiplicity. Our findings suggest most USP planets originated via inward migration driven by tidal dissipation over Gyr timescales. This work reveals the age-dependence of USP planet systems' occurrence and architecture, providing new constraints for future studies to further distinguish between different formation mechanisms of USP planets.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

ISOLATING PIXEL-LEVEL SPECTRAL VARIABILITY IN THE SUN ACROSS TIME AND SPACE WITH MULTI-INSTRUMENT EPRV DATASETS

Ryan Rubenzahl &
Megan Bedell, Michael Palumbo, Kate Hobbs, Jacob Luhn, Soichiro Hattori
Flatiron Institute; Flatiron Institute, Flatiron Institute, Queen's University Belfast/Flatiron Institute, JPL, Columbia University

The discovery and characterization of Earth-analogs with radial velocities will require 10 cm/s sensitivity over multi-year observing campaigns. Instrumental and stellar variability across a range of timescales and amplitudes complicate this goal. High signal-to-noise observations of the Sun, made hundreds of times every day by EPRV solar feeds, provide a direct means to resolve subtle spectral variability across all timescales; by comparing between multiple instruments, stellar variability can be disentangled from instrumental drift. We analyzed one year of KPF, NEID, EXPRES, and HARPS-N solar data at the line-by-line and pixel-by-pixel level to isolate common (astrophysical) from uncommon signals (instrumental). We map instrumental changes across the detector to diagnose sources of drift, and map solar variability to layers of the solar atmosphere by modeling the formation temperature of each spectral segment. We developed a novel exposure-time-aware Gaussian process method to efficiently handle the computational challenge of separating these signals in the time domain to trace how oscillations, granulation, supergranulation, and rotationally modulated effects themselves change throughout the solar atmosphere. Finally, I will show correlations of pixel-level variability with SDO images which reveal which parts of the spectrum are most sensitive to spots and plage. This will inform identifications of families of lines which may be leveraged to extract pristine Doppler shifts amongst these line shape changes.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

EVERY LINE MATTERS: SEPARATING PLANETARY AND STELLAR SIGNALS VIA LINE-BY-LINE ANALYSIS OF EPRV SURVEYS

Eric Ford &
Joseph M. Salzer, Kanishk Pandey, Cullen H. Blake, Jessi Cisewski-Kehe, Suvrath Mahadevan
Penn State; Univ. Wisconsin Madison, Penn State, Univ. Pennsylvania, Univ. Wisconsin Madison, Penn State

The current generation of extremely precise radial velocity (EPRV) spectrographs are approaching the precision needed to detect rocky planets in the habitable zone of sun-like stars. Traditionally, astronomers analyze a single time-series of velocities extracted from each spectrum to detect and characterize low-mass planets. However, this approach discards rich information about changes in the location, depths, widths, and shape of each of thousands of spectral lines. Measuring the properties of each line individually provides a potential path towards separating true planetary signals from stellar variability, uncalibrated instrumental effects, and telluric contamination. Leveraging the high stability of the NEID spectrometer, our team has been developing and evaluating multiple approaches for analyzing and interpreting the resulting high-dimensional time series. For example, in Salzer et al. (2025) we developed a linear fixed effects models that combine line-by-line shape information to reduce the RMS residuals for NEID solar observations from over 2m/s to ~40-60cm/s. We will provide a brief overview of this and other recent innovations, such as identifying and grouping lines that behave similarly. We will show how such analyses can be useful for diagnosing lines which are most affected by stellar variability, undetected blends, telluric contamination, or imperfect wavelength calibration. We compare results from line-by-line methods using NEID solar observations and discuss recent improvements in the cross validation process when evaluating the performance of different methods for mitigating stellar variability. Finally, we discuss opportunities for similar techniques to improve the interpretation of Rossiter-McLaughlin and transmission spectroscopy observations.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

TRACING THE SPECTRAL FINGERPRINTS OF SUNSPOTS AND PLAGE ACROSS THE OPTICAL SPECTRUM

Katlyn Hobbs &
Ryan Rubenzahl, Megan Bedell
Queen's University Belfast; Center for Computational Astrophysics, Flatiron Institute, 162 Fifth Avenue, New York, NY 10010, USA

"Spectral Differencing Analysis (SDA) is a powerful technique for isolating the spectral signatures of stellar activity. Magnetic activity in cool stars drives spectral line variability, introducing noise that can mask planetary radial velocity signals. Active regions such as spots and plage are responsible for these line distortions, and while numerous mitigation techniques have been developed, the individual contributions of these active regions remain poorly understood.
Characterising the spectral line shape changes due to these active regions is therefore crucial for distinguishing radial velocity signals caused by stellar activity from those produced by an orbiting planet. I will discuss how we apply SDA to Sun-as-a-star observations, comparing active and inactive spectra over multiple solar rotation cycles. The resulting difference spectra isolate the spectral signatures associated with solar magnetic activity on the level of individual spectral lines.
To separate genuine solar signals from instrumental systematics, we compare contemporaneous solar spectra obtained with HARPS-N, NEID, and KPF SoCal. The use of multiple, independent instruments enables us to confirm subtle activity-driven features. By correlating spectral variability across instruments and further comparing these signals with plage and spot surface area coverage derived from Solar Dynamics Observatory (SDO) images, we distinguish activity-driven variability from instrumental effects and investigate its connection to magnetic structures on the stellar surface. Across the full optical range, we identify spectral regions that are sensitive to these magnetic features on a pixel-by-pixel basis, advancing our understanding of activity-driven line-shape changes and enabling more effective mitigation of stellar activity in the search for Earth-like exoplanets."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

FIRST DETECTION OF STELLAR GRANULATION AND OSCILLATIONS FROM JWST EXOPLANET LIGHT CURVES

Angharad Weeks
University of Sydney

“A detailed understanding of stars underpins much of modern astronomy, including exoplanet detection, characterization, and atmospheric studies. In addition to exoplanet atmospheres, the unprecedented precision of JWST infrared time series data can be used to study the stars, as both stellar granulation and oscillations cause photometric variability at amplitudes comparable to planet transits.
In this talk we present results from a search of NIRISS/SOSS data for stellar variability: the first observations of solar-like oscillations and granulation at infrared wavelengths. We characterise the amplitudes and timescales of these processes using Gaussian Process methods, and discuss the future implications of this discovery, particularly the potential for exciting synergies between the fields of asteroseismology and exoplanet atmospheres.”

STELLAR GRANULATION-INDUCED VARIABILITY ACROSS THE OPTICAL SPECTRUM

Cis Lagae &
Ginger Frame, Heather Cegla
University of Warwick

Radial velocity noise from the exoplanet hosting star, originating from stellar activity such as faculae and granulation, hampers the detection and characterization of earth-mass exoplanets. A profound understanding of how spectral lines behave in the presence of these stellar components is necessary to eliminate such radial velocity noise from observations. In this context, we have build a framework that isolates and characterizes the radial velocity signature due to granulation for individual, synthetic, spectral lines computed from 3D stellar models. Building on this, we expanded the method to larger spectral regions, including tens of spectral lines, with the goal of mimicking real disk-integrated stellar observations. Using this method, we have quantified how granulation affects the properties and radial velocities of spectral lines differentially, from disk centre to the stellar limb. We found that certain groups of lines behave radically different than others, based on their atomic parameters and line depth. In addition, we investigated how different methods of computing radial velocities affect these relationships. Ultimately, this work will enable us to identify key granulation noise diagnostics across the optical spectrum that can be used to reduce the granulation-induces radial velocity noise from observations.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

A HIERARCHICAL MODEL FOR UNDERSTANDING STELLAR MAGNETIC ACTIVITY

Sabrina Sagynbayeva &
Will Farr

Stony Brook University; Stony Brook University, Flatiron Institute

"Stellar magnetic activity poses a major challenge to the characterization of exoplanet atmospheres. Evolving starspots can introduce astrophysical noise that masks or mimics atmospheric signals, potentially leading to false positive detections or biased measurements. This is especially pertinent for ongoing observatories like JWST, which studies the atmospheres of small planets orbiting Sun-like stars that often exhibit strong magnetic activity. Disentangling stellar and planetary signals is therefore critical for robustly measuring exoplanet atmospheric properties.

In this talk, I will showcase the novel technique for mapping the evolving starspot distributions on exoplanet host stars observed by Kepler and TESS. Our hierarchical Bayesian approach uses Gaussian processes to infer key starspot properties like typical sizes, active latitudes, and lifetimes from the photometric variability induced by spots rotating in and out of view. Crucially, by leveraging the abundant transits of exoplanets, some of which cross over spots, we can break degeneracies in the spot modeling to infer stellar and starspots parameters. Simultaneously, transiting exoplanets provide a novel probe of stellar magnetic activity and spin-orbit misalignments, illuminating the formation and evolution of planetary systems. I will discuss the implications of our results for both fields and highlight the potential of our flexible technique in the era of precise time-domain photometry."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

MODELING ACTIVITY-DRIVEN SIGNALS IN PHOTOMETRY AND RADIAL VELOCITIES FOR EXOPLANET DETECTION

Alba Barka &
Nuno Santos, Ângela Santos, Eduardo Cristo, Khaled Al Moulla
IA/FCUP, Université Paris-Saclay

"Advances in high-precision spectroscopy have pushed radial velocity (RV) measurements toward 10 cm/s precision. Stellar physical phenomena remain, however, a major source of noise, as they can mimic or obscure planetary signals. In this context, the Sun provides a unique benchmark to investigate these effects in detail. In this work, we model the RV and photometric variations induced by solar activity, specifically spots and faculae, using the SOAPv4 code. Active regions are identified from SDO/HMI and AIA images using different methods, and their impact is simulated and compared with Sun-as-a-star RV measurements from HARPS-N and photometry from VIRGO/SPM. After subtracting the modelled activity signals, the standard deviation of the RV residuals is reduced to 0.90 m/s over a timespan of 543 days, approaching the 80 cm/s granulation
limit reported in literature. This precision is constrained by incomplete physical modelling, which, with further refinement, could enable the 10 cm/s precision needed to detect Earth-like exoplanets. We show that the choice of active-region identification method has a strong impact on the modelled RVs, leading to significantly different levels of activity correction. We also present preliminary results from a new implementation of SOAP in which active regions are treated at the pixel level. This new version will improve the modelling of active regions, enabling a more realistic representation of solar magnetic structures. The potential of future PoET data will be discussed."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

ACCURATE, PRECISE, AND HOMOGENEOUS HOST STAR PARAMETERS ENABLE UNPRECEDENTED AGE PRECISION FROM JWST TRANSIT LIGHT CURVES

Patrick McCreery &
Kevin Schlaufman (1); Henrique Reggiani (2); Zafar Rustamkulov (3)
Johns Hopkins University; (1) Johns Hopkins University; (2) NOIRLab, Gemini South; (3) IPAC at Caltech

Determining the age of an isolated field star is one of the most challenging inferences in astronomy, especially for hot Jupiter systems that may have experienced angular momentum exchange that violates the assumptions of most age–stellar rotation calibrations (i.e., gyrochronology). One promising alternative approach to the age inference problem is to use 1% precision host star mean density measurements based on James Webb Space Telescope (JWST) mid infrared transit light curves of hot Jupiters that are substantially unaffected by stellar limb darkening. Using these density measurements as constraints on state-of-the-art stellar age inferences based on all available Gaia astrometry, multiwavelength photometry from the ultraviolet to the mid infrared, and high-resolution spectroscopy results in age precisions exceeding similar approaches based on short-cadence Kepler asteroseismology of its LEGACY sample. Supporting its accuracy, our approach produces 1% precision stellar masses and radii consistent with star–planet SB2 solutions and interferometric measurements for nearby stars, along with precise photospheric elemental abundances. Applying our approach to the sample of 12 hot Jupiter hosting stars observed in the JWST Grand Tour program, we obtain unparalleled age precisions. As an example, for the JWST Cycle 1 target HD 189733, we find an age consistent with previous inferences but nearly an order of magnitude more precise. HD 189733 is rotating more quickly than open cluster K dwarfs of similar masses and ages, and we interpret its excess angular momentum as evidence of approximately 0.04 AU of inward tidal migration by HD 189733 b. Over its expected 10-year lifetime, we expect JWST light curves for hundreds of transiting giant planets to yield similarly precise age inferences and enable precise studies of the time evolution of giant planet systems.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

COMMISSIONING AND FIRST LIGHT OF HARPS3 ON THE AUTOMATED ISAAC NEWTON TELESCOPE

Clark Baker &
The HARPS3 team
University of Cambridge / ETH Zürich

"The High Accuracy Radial velocity Planet Searcher 3 (HARPS3) is an ultra stable, high resolution (R ≈ 115,000), visible (380-690nm), fibre-fed echelle spectrograph constructed to deliver long term extreme-precision radial velocity (EPRV) data as required by the Terra Hunting Experiment (THE). The THE will be the most intensive radial velocity survey to date, searching for Earth-twin planets around nearby, G-K dwarf, Sun-like stars; observing these stars every night they are visible over the span of a decade.
Built as an iteration on the HARPS and HARPS N design, HARPS3 applies an enhanced continuous flow cryostat detector unit system, improved grating stability, greater star guiding accuracy and, soon, a full-waveband laser frequency comb (LFC) calibration system. After successful lab assembly, integration and testing (AIT) at Cambridge, the disassembled HARPS3 arrived in two shipping containers at the Isaac Newton Telescope (INT) in October 2025; with installation and commissioning taking place over winter 2025 – spring 2026. HARPS3's installation coincides with the completion of the INT's transformation into a fully robotic facility, which, alongside an automated scheduler system, enables long-term nightly-cadence radial velocity monitoring campaigns.
We present the status of HARPS3's commissioning at the now automated INT, including on-site AIT, first light operations and early on sky performance with an outlook on upcoming performance verification milestones, as HARPS3 transitions toward full survey operations on the robotic INT.
50% of the time with HARPS3@INT will be available for open time observations through the Isaac Newton Group of Telescopes (ING)."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

TARGET SELECTION FOR THE SECOND EARTH SPECTROGRAPH (2ES): A SYSTEMATIC SEARCH FOR EARTH ANALOGUES

Jinglin Zhao &
Launhardt, Ralf, Lars A. Buchhave, Trifon Trifonov, Rafael Brahm, Thomas Henning
DTU Space; MPIA, DTU Space, Universidad Adolfo Ibáñez

"We present the target-selection strategy for the Second Earth Spectrograph (2ES), a next-generation extreme-precision radial-velocity (RV) instrument on the MPG/ESO 2.2 m telescope. 2ES will observe approximately 30 southern stars nightly for 5 years, aiming to detect Earth analogues around nearby solar-type stars. To avoid the incompleteness and inhomogeneity of legacy target lists, we developed an automated pipeline that queries Gaia DR2/DR3 directly and compiles a uniform sample of bright, nearby FGK main-sequence stars.
Reaching habitable-zone sensitivity to Earth-mass planets requires RV precision at the ~10 cm/s level, where stellar variability dominates over photon and instrumental noise. For each candidate star we predict the achievable RV precision by accounting for four noise terms: instrumental stability, photon noise, p-mode oscillations (reduced with 10-minute exposures), and granulation/supergranulation. We then compute habitable-zone boundaries and the minimum detectable planet mass required to beat the combined noise budget.
Applying this framework identifies 256 stars for which sub-Earth-mass planets are in principle detectable in the habitable zone. Cross-matching highlights strong program synergies: 27 targets host confirmed TESS planets, 10 are in PLATO LOPS2, and 54 appear on NASA's Habitable Worlds Observatory target list. We then perform homogeneous manual vetting to down-select the optimal 30-star 2ES program.
Our pipeline is publicly available and readily adaptable to other Earth-analogue RV surveys (e.g., the Terra Hunting Experiment), providing the exoplanet community quick access to a reproducible framework for optimizing extreme-precision RV surveys targeting potentially habitable worlds around nearby solar-type stars."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

AN UPDATE ON THE SPECULOOS SURVEY: HUNTING SMALL PLANETS AROUND THE COOLEST STARS

Mathilde Timmermans
University of Birmingham

The SPECULOOS survey has been monitoring the brightness of hundreds of ultracool stars in the past decade. The project aims at discovering new promising targets for atmospheric characterization with JWST by finding small habitable rocky planets transiting their host stars. It uses a network of robotic telescopes (1m-class) located in Chile, Mexico and Tenerife, to target a sample of about 1700 very low-mass stars in a 40 pc volume-limited sample. Such a survey allows to study terrestrial planets orbiting ultracool stars on a population level, as well as understand the activity of these stars thanks to our long-term monitoring strategy. In this talk, I will present an update on the status of the survey, discuss our strategy, and highlight our discoveries since the TRAPPIST-1 system. Notably, the SPECULOOS-2 system hosts two rocky planets orbiting an M6 star, with the outer planet lying in its habitable zone. The most recent SPECULOOS-3 system has an Earth-sized planet on a 17h-orbit transiting an M6.5 star, making it an ideal candidate for emission spectroscopy. With 15 out of 24 planets discovered or co-discovered in this key regime, including four of the five potentially habitable ones and the only cold case, SPECULOOS has played a leading role in shaping the landscape of small transiting rocky planets orbiting nearby low-mass (<0.2 M⊙) M dwarfs — the very best targets for JWST atmospheric studies.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

SMALL CIRCUMBINARY PLANETS ARE TRULY RARER THAN SMALL SINGLE-STAR PLANETS

David Martin &
Wata Tubthong (1); Daniel C. Fabrycky (2); Tess Kleanthous (1)
(1) Tufts University; (2) University of Chicago

Despite the super-Earths and sub-Neptunes making up ~80% of the planet population around single stars, there is an apparent lack of such planets around binary stars. This is owing to the inherently biased nature of the by-eye discoveries of CBPs. Understanding the population of circumbinary super-Earth and sub-Neptunes (or the lack thereof) would shed light into the formation and evolution of planetary systems in a completely different environment than ours. We applied STANLEY, an automated algorithm that employs an N-body simulation to account for TTV, to Kepler eclipsing binary light curves to search for small CBPs. For the first time, we are able to constrain the occurrence of circumbinary sub-Neptunes and demonstrate that the CBPs between 2-3 Earth radii are 8σ rarer than their single-star counterparts.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

MASSES OF DIRECTLY-IMAGED PLANETS VIA ULTRA-HIGH PRECISION ASTROMETRY WITH THE HABITABLE WORLDS OBSERVATORY

Kaz Gary &
B. Scott Gaudi, Eduardo Bendek
The Ohio State University; The Ohio State University, NASA Ames Research Center

Constraints on the masses of exoplanets directly imaged and characterized by the Habitable Worlds Observatory (HWO) are crucial for categorizing these planets and interpreting their spectra. In particular, achieving a mass measurement with a precision of approximately 10% or better may be necessary to identify the dominant gaseous species in the atmospheres of Earth-like planets. This, in turn, is essential for assessing their potential habitability and interpret potential biosignatures (Damiano et al. 2025). Space-based astrometry will be required to measure the masses of planets in face-on systems, or planets orbiting hot and rapidly rotating or highly active stars. Astrometric uncertainties are dominated by the number and magnitude of background reference stars needed to precisely measure the astrometric wobble of the target star induced by the planet. To that end, we propose a program to measure the masses of Earth analogs orbiting HWO target stars with ultra-high-precision astrometry obtained with the HWO high-resolution instrument. We assess the photon-noise error budget for these observations. We find that, for a field of view spanning a few square arcminutes, the astrometric uncertainty due to the number and brightness of reference stars dominates the photon-noise error budget, particularly for targets near the Galactic poles. We explored the impact of filter choice and location in the sky on the photon-noise astrometric uncertainties by simulating the magnitude distribution of reference stars across different filters at a range of galactic longitudes and latitudes. We find that, from our reference star simulations, a ~ 200-day survey in the Gaia G band consisting of 100 epochs per target star distributed over the 5-year prime mission with a 6m aperture HWO equipped with a 6′ x 6′ field-of-view would be required to achieve the photon-noise sensitivity to measure the masses of the ~ 40 Earth-mass habitable-zone planets to ~ 10%. We then estimate the astrometric uncertainty of these observations, given only photon-noise, for potential target stars on the HWO ExEP Precursor Science Stars List using GAIA data to find the number of available reference stars in a 6′ x 6′ field-of-view around each of our target stars.

ROOM 3

30/06 17:45–18:00

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

USE THE 4S: A SYSTEMATIC RE-ANALYSIS OF VLT/NACO DATA WITH EXPLAINABLE MACHINE LEARNING

Markus Bonse &

Timothy D. Gebhard, Felix A. Dannert, Gilles Orban de Xivry, Robert J. De Rosa, Olivier Absil, Faustine Cantalloube, Valentin Christiaens, Gabriele Cugno, Emily O. Garvin, Jean Hayoz, Markus Kasper, Elisabeth Matthews, Sascha P. Quanz, Bernhard Schölkopf

ESO

“The main challenge in exoplanet high-contrast imaging (HCI) is to separate the faint planetary signal from the bright glare of its host star. For ground-based observations, speckle noise from atmospheric turbulence and optical imperfections exacerbates this problem. Post-processing techniques aim to suppress this speckle noise, but they often remove part of the signal in the process.

We employ explainable machine learning to investigate why one of the most commonly used methods, principal component analysis (PCA), tends to over-subtract the planet. We demonstrate that PCA learns a representation of the noise which overlaps with the characteristic shape of the planetary signal. Building on these insights, we introduce a new algorithm called 4S, which constrains the noise model to preserve the planet’s signal. 4S achieves up to 1.5 magnitudes deeper contrast at small angular separations (<4lambda/D), opening up a new discovery space for exoplanet imaging.

To exploit this gain, we uniformly reprocessed the entire VLT/NACO archive obtained in L'-band pupil tracking mode between 2009 and 2019. The complete sample comprises 560 stars and incorporates extensive surveys such as NaCo-ISPY, making it one of the largest archival searches ever conducted for exoplanet imaging. The enhanced detection capabilities of 4S allow for five pre-discovery recoveries, including the exoplanet AF Lep b in data from 2011— eleven years before its reported discovery — and identify sixteen new companion candidates, which are now being followed up in a dedicated 50-hour VLT/ERIS program.

Finally, we derive detection limits for coronagraphic and non-coronagraphic observations with VLT/NaCo and VLT/ERIS. Surprisingly, non-coronagraphic VLT/NaCo data outperformed coronagraphic observations in both contrast- and background-limited regimes by approximately one magnitude. A direct comparison of the detection limits provides practical guidance for future L’-band surveys with VLT/ERIS and the coronagraph design of ELT/METRIS.”

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

HIGH-CONTRAST OBSERVATIONS WITH ELT-ANDES: EXOPLANET YIELDS WITH END-TO-END SIMULATIONS

Adrien Simonnin &
M. N'Diaye(1), M. Houllé(2), G. Chauvin(3), A. Chiavassa(1), V. Parmentier(1), E. Pinna(4), G. Agapito(4), G.Carlà(4), C. Selmi(4), A. Spang(1), P. Berio(1), J.Seidel(1)

Lunds University, (1) Observatoire de la Côte d'Azur, (2) Institut de Planetologie et d'Astrophysique de Grenoble, (3) Max Planck Institute for Astronomy, (4) INAF – Osservatorio Astrofisico di Arcetri

"Combining high-contrast imaging with high-dispersion spectroscopy is a promising solution to detect exoplanets and spectrally analyze their atmosphere. Such an approach is envisioned for ELT-ANDES, a high-resolution spectrograph with high-contrast capabilities. In the near infrared, this facility will feature a single-conjugate adaptive optics (SCAO) system, a possible coronagraph module, and an integral field unit (IFU) spectrograph with a resolving power of 100000. Such a combination is expected to enable the observations of planets around nearby stars with a planet-to-star flux ratio, i.e. contrast, down to 10-7 in Y, J and H bands.
This study assesses the capabilities of the ANDES SCAO-IFU module, both with and without the coronagraph, for directly detecting young giant exoplanets. To this aim, we have developed end-to-end simulator of ANDES, APU for ""ANDES Performances Unfolded"". This tool reproduces all steps from high-contrast image generation, photometric and noise modeling, to the injection of astrophysical scenes and final data analysis. Using APU, we simulate high-contrast observations under different observing conditions and for different astrophysical scenes. With the produced data, the signal from the injected exoplanets is retrieved by using the molecular mapping technique.
We applied APU to a science case involving young Jupiters from L to T spectral type detected via direct imaging. Under excellent seeing conditions, the results show that planets with contrasts down to 10–7 could be detected at angular separations as small as 30 mas. These simulations emphasize the potential of ANDES for high-contrast exoplanet observations.
The presentation concludes by outlining future prospects for the APU simulator, which will be made public in the following month. This tool will be crucial to help the community to prepare for the arrival of ANDES in 2035."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

CORGI-REX: REFERENCE STAR VETTING FOR THE ROMAN CORONAGRAPH INSTRUMENT WITH HIGH-CONTRAST IMAGING FROM VLT/SPHERE

Macarena Vega Pallauta &
Justin Hom, Schuyler G. Wolff, Wolfgang Brandner, Gaël Chauvin, Vanessa P. Bailey, Beth A. Biller, Marah Brinjikji, Catherine Clark, Robert J. De Rosa, Julien H. Girard, Alexandra Z. Greenbaum, Masayuki Kuzuhara, Bruce Macintosh, Alan Medina, Maxwell A. Millar-Blanchaer, Toshiyuki Mizuki, Brooke Okpaku, Nicholas T. Schragal, Jason J. Wang, Jingwen Zhang

Max-Planck Institute for Astronomy; U. Arizona, JPL, U. Edinburgh, U. Notre Dame, CalTech/IPAC, ESO, STScI, ABC/NAOJ, UCSC, UCSB, Northwestern

"Most known exoplanets have been discovered via radial velocity and transit surveys, favoring hot, short-period planets. To explore cold and temperate long-period exoplanets, direct imaging is essential. The Nancy Grace Roman Space Telescope, scheduled to launch in late 2026, will carry the first space-based coronagraph capable of directly imaging mature, cold exoplanets in reflected light, marking a major step toward imaging Earth-like planets and paving the way for a next generation of facilities such as the Habitable Worlds Observatory (HWO) and the Extremely Large Telescope (ELT).
The primary requirement for the Roman Coronagraph Instrument is achieving the extreme high contrast needed to detect faint planets, with expected contrast ratios of 1E-9 (comparable to the Sun–Jupiter brightness ratio at visual wavelengths). This performance will be achieved by suppressing stellar speckle noise through active optics and an observing strategy that alternates between science targets and carefully selected reference stars. Reference stars must be bright (V < 3), small (angular diameter < 2 mas), and single, as even faint companions can degrade contrast through flux leakage into the "dark hole". Characterizing these reference stars requires high-contrast imaging to rule out such companions.
As part of the broader CorGI-REx campaign, we present results from high-contrast imaging with VLT/SPHERE of 23 candidate reference stars from archival and dedicated observations. We have identified 31 previously unreported companions around 10 stars. We perform photometric and astrometric characterization to confirm whether they are bound or background objects, and to asses the potential impact in the High-Order Wavefront Sensing and Control (HOWFSC). From the ensemble of observations, we derive median detection limits of Δmag ~ 14 at 0.5" and Δmag ~ 16.5 at 1.5" in H band, sufficient to rule out M-type companions."

EXOPLANETS
PORTO
2026

CONFERENCE ABSTRACTS E-BOOK

WEDNESDAY, JULY 01

LINKING INTERIORS AND ATMOSPHERES IN SUPER-EARTHS AND SUB-NEPTUNES

Caroline Dorn
ETH Zurich

It's been nearly 20 years since PLATO was first proposed to ESA and now we are just a few months away from launch (20th January 2027) – it's been a long journey. PLATO will be sensitive to Earth-Sun analogs around nearby stars. In this talk I will summarise the mission and its science objectives along with its dedicated ground-based observation programme. I'll also give details of the mission data products and when they will be made public (the bulk of the data and associated photometric data products, becoming available within 3 months of the end of an observation). The PLATO mission consortium has always been, and will continue to be, open to members of the scientific community and we encourage researchers to get involved.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

BRIDGING SOLAR SYSTEM EVOLUTION AND EXOPLANET SCIENCE

Hilke Schlichting &
Ankan surRoberto Tejada Arevalo, Adam Burrows
UCLA, University of California Los Angeles, Princeton University

Juno and Cassini have transformed our understanding of the interior structures of the solar system's gas giants. Their gravity measurements reveal that both Jupiter and Saturn likely possess dilute or "fuzzy" cores, rather than the traditional compact ones. This finding has profound implications for how heat and heavy elements are transported within these planets, influencing their thermal evolution, luminosities, and atmospheric metallicities. In this talk, I present the first evolutionary models of Jupiter and Saturn, using our code APPLE, that self-consistently incorporate fuzzy cores, helium rain, ammonia cloud physics, and unified microphysics, successfully reproducing each planet's thermal, compositional, and gravity constraints. I further discuss how these insights extend to gas-giant exoplanets, highlighting differences and similarities with the heritage Sonora Bobcat model suite. Lastly, I will talk about recent advances in modeling the evolution of solar system ice giants and sub-Neptune type exoplanets within our APPLE framework.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

A HOMOGENEOUS SURVEY OF FGK-HOST GAS GIANTS WITH JWST

Tyler Fairnington &
Michael Radica, Eliza Kempton, Jacob Bean, Michael Zhang, Matt Nixon, Jegug Ih
University of Chicago, Arizona State University, Space Telescope Science Institute

"Constraining the formation history of giant planets requires moving from individual case studies to robust population-level statistics. We present the first homogeneous reduction, retrieval, and population analysis of 26 transiting gas giants (> 20 Mearth) orbiting FGK stars observed during JWST Cycles 1–4, combining NIRISS and NIRSpec transmission spectroscopy across 1-5 microns. To mitigate the ""human factor"" in data reduction, we deploy an autonomous optimization routine for the exoTEDRF pipeline designed to eliminate manual knob-turning and objectively maximize spectral precision.
We perform hierarchical Bayesian atmospheric retrievals to infer metallicities and assess population-level trends. In this talk, I will present the survey results including the initial population-level constraints on the mass–metallicity relation, highlighting how JWST is enabling the first statistically robust tests of long-standing formation predictions."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

JWST'S FIRST LOOK AT THE DISINTEGRATING TERRESTRIAL PLANET BD+05 4868AB

Marc Hon &
Nick Tusay, Saul Rappaport
National University of Singapore, University of Washington, MIT

The cataclysmic evaporation of BD+05 4868Ab into a comet-like dust tail offers an unprecedented opportunity to directly infer the composition of a rocky planet outside our Solar System. In this talk, I present JWST/MIRI LRS slitless spectroscopy of two transits of the system, yielding phase-resolved transmission spectra along the dust tail. By comparing these spectra to extinction and scattering models for candidate minerals, we infer the dust's mineralogical content, providing a first glimpse of the elemental make-up of the planet's interior. I will highlight an unusually sharp mid-infrared feature that is difficult to reproduce with standard mixtures of silicate grains, suggesting either non-standard grain physics or an unexpected dust composition. Finally, I will show how the inferred grain sizes and compositions evolve along the tail, constraining the dust temperature and the spatial extent of the tail as a proxy for the survival and dynamics of the debris around the star.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

MAGNETIC RADIO EMISSION FROM THE β PICTORIS EXOPLANETARY SYSTEM

Kevin Ortiz Ceballos &
Edo Berger, Yvette Cendes
Center for Astrophysics | Harvard & Smithsonian, University of Oregon

We report the detection of multiple recurring, highly circularly polarized radio bursts from the β Pictoris system, observed in L-band (0.8-1.7 GHz) with the MeerKAT array. The burst properties are consistent with electron cyclotron maser emission, analogous to auroral radio bursts observed from magnetized brown dwarfs and Solar System planets. We interpret the emission as originating from one of the massive planets in the system, most likely β Pictoris b. The inferred burst frequencies imply a local magnetic field strength of at least 600 G, consistent with modeling predictions for the magnetic fields of the β Pictoris planets but more than twice the empirical upper limits on the stellar magnetic field. This detection provides a direct measurement of the strength of a planetary magnetic field beyond the Solar System, and points to coherent radio emission as a key tracer for constraining planetary dynamos and magnetospheric processes.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

FROM GAS GIANTS TO ROCKY WORLDS: ADVANCES FROM HIGH RESOLUTION SPECTROSCOPY OF EXOPLANET ATMOSPHERES

Jayne Birkby
University of Oxford

Over the last decade, high resolution spectroscopy has taken a leading role in the detailed characterisation of giant exoplanets, determining not only their chemistry and structure but also their time-resolved atmospheric dynamics, from rotation rates to equatorial jets and day-night winds, and even assessing their magnetic fields. Recent progress is pushing the technique towards the characterisation of smaller planets such as sub-Neptunes and lava planets, aiming to unlock its enormous potential to study nearby habitable worlds with the Extremely Large Telescopes. ELT first light is due in just over three years; are we ready? In this talk I will highlight some of the most recent and astounding discoveries from HRS of exoplanet atmospheres and their impact in advancing our understanding of planet formation, evolution, and climate. But, I will also underline the challenges we face in using HRS to study rocky exoplanets that need solving in the next 3 years, before the era of the ELTs, and how missions such as PLATO, Gaia, and JWST will help us do this.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

JOINT HIGH- AND LOW-RESOLUTION ANALYSIS OF WASP-107B'S ATMOSPHERE: COMBINED STRENGTHS AND INTRINSIC OBSERVATIONAL LIMITS

Francesco Amadori &
Paolo Giacobbe (1), Matteo Brogi (2)

(1) National Institute of Astrophysics – Astrophysical Observatory of Turin, (2) University of Turin

The atmospheric characterization of Neptune-mass exoplanets serves as a crucial stepping stone toward understanding smaller, potentially habitable worlds. This study presents a comprehensive multi-resolution analysis of WASP-107b, a warm super-Neptune with an extended atmosphere ideal for transmission spectroscopy. Our purpose is to combine high-resolution (HR) ground-based observations (TNG/GIANO-B, GEMINI SOUTH/IGRINS) with low-resolution (LR) space-based data (HST/WFC3, JWST/NIRCam, JWST/MIRI). Combining HR and LR spectroscopy provides complementary atmospheric constraints. HR resolves molecular absorption into unique line forests, disentangling overlapping spectral signatures between primary and secondary species. It probes the upper atmospheric layers and penetrates through clouds. LR preserves continuum information essential for measuring absolute abundances and probes lower atmospheric regions. This multi-resolution approach enables complete vertical atmospheric coverage while providing tighter constraints on molecular detections. We first validated previous LR studies, confirming strong spectral signatures of CO_2, CO, H_2O, and SO_2, along with weaker signatures of NH_3 and CH_4. For the HR analysis, we combined two transits from GIANO-B (0.95–2.45 μm) with three transits from IGRINS (1.45–2.45 μm), both providing $R \simeq 48{,}000$. After disentangling the planetary signal from telluric and stellar contamination using Principal Component Analysis, we applied cross-correlation techniques to assess whether LR-detected molecules are detectable at HR and to search for additional secondary species. Finally, the combined analysis is completed through a Bayesian atmospheric retrieval that simultaneously fits both datasets, leveraging their complementary capabilities to provide tighter constraints on atmospheric composition and structure. A fundamental observational challenge for this planetary class emerges from their orbital dynamics. Unlike hot Jupiters ($K_p > 140$ km/s), where planetary and telluric signals separate cleanly in velocity space, warm Neptunes like WASP-107b ($K_p \simeq 105$ km/s) experience significant velocity overlap between planetary and telluric features, limiting molecular identification at HR. This challenge becomes increasingly critical for Earth-sized and super-Earth targets. While upcoming Extremely Large Telescopes will enhance sensitivity through greater collecting power, the velocity overlap represents a fundamental systematic limitation requiring advanced techniques to disentangle planetary from stellar and telluric signals for reliable ground-based characterization of terrestrial exoplanet atmospheres.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THREE YEARS OF ATMOSPHERIC CHARACTERIZATION WITH THE NEAR INFRA-RED PLANET SEARCHER (NIRPS)

Romain Allart &
Stefan Pelletier, Valentina Vaulato, Yann Carteret, Luc Bazinet, Ana Rita Costa Silva, Vincent Bourrier, Etienne Artigau, François Bouchy, René Doyon, and the NIRPS consortium

Université de Montréal, Université de Genève, Universidade do Porto, Université de Grenoble Alpes, Universidade Federal do Rio Grande do Norte, Instituto de Astrofísica de Canarias

NIRPS is a fiber-fed high spectral resolution spectrograph assisted by adaptive optics installed on the 3.6m telescope of ESO at LaSilla, Chile. Operated simultaneously with HARPS, NIRPS covers the Y, J, and H bands. In this talk, I will describe the objectives of the NIRPS consortium that has been allocated 725 GTO nights over 5 years. A third of this time is dedicated to in-depth spectral characterizations, to provide detailed, high-fidelity, high signal-to-noise transmission and emission spectra in preparation for the ELT era, as well as large, comprehensive atmospheric and orbital architecture surveys with the goal to observe over 70 exoplanets, ranging from ultra-hot Jupiters to temperate terrestrial planets. Over the program's first half, we have prioritized the best exoplanets across the exoplanet population, including many JWST targets. For the second part of our program, we have tighten our objectives by conducting 1) an in-depth characterization of a handful of exoplanets to study their atmospheres over 5 years; 2) a transit survey of hot Jupiters and puffy Neptunes to characterize their atmospheric composition; 3) an helium survey to understand the correlation between the Neptunian desert-ridge-savanna, mass loss rate and orbital architecture; and 4) an emission survey to constrain the condensation phase and the photo-dissociation of water in ultra-hot Jupiters. During the talk, I will highlight key results we have obtained since the start of operations, including detections of escaping atmospheres, atmospheric variability, and constraints on the atmospheric composition of warm Neptunes to hot Jupiters. I will then present, in more detail, a first statistical analysis of the atmospheric escape and composition for a sample of 20-30 exoplanets we observed. These results will showcase the potential of NIRPS to deliver high-fidelity atmospheric spectra to constrain the formation and evolution of exoplanets at the statistical level. Furthermore, I will demonstrate, for one of our keystone exoplanets, WASP-127b, how NIRPS observations can be combined with JWST observations to place stringent constraints on its atmospheric properties, from composition to dynamics. Looking ahead, I will discuss how extending NIRPS into the K band will unlock a new realm of atmospheric science, enhancing and securing long-term follow-up of exoplanet atmospheres to study their variability. Finally, NIRPS lays the groundwork for ELT spectrographs such as ANDES, and I will showcase how the lessons learned from NIRPS can be applied to the next generation of state-of-the-art instruments.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

PROBING ATMOSPHERIC MASS LOSS AT DISK DISPERSION TIMESCALES

Jaume Orell Miquel &
Caroline Morley
University of Texas at Austin

"During the earliest stages of planetary formation, exoplanets undergo rapid changes in their physical and atmospheric properties, which are driven by internal and external forces. The intense irradiation from the young host star and the internal heat released from the core contraction can cause atmospheric inflation and evaporation, reshaping planets on timescales of less than 100 Myr. Studying the limited sample of planets at these young ages provides a unique opportunity to directly test theories of planet formation and atmospheric evolution, especially those related to photoevaporation and the origin of the observed demographics of mature exoplanet.

In this context, the newly discovered TOI-6963b is the youngest known transiting exoplanet with only 3 Myr, making it a unique benchmark for testing theories of early atmospheric evolution. Because it is so young, the protoplanetary disk surrounding the host star has not fully dissipated yet. This places the planet in a regime where disk-driven environments and extreme stellar activity may strongly influence atmospheric escape. This system provides an unprecedented opportunity to investigate whether photoevaporation and other mass-loss processes are already active in the earliest observable stages of planetary evolution.

In this talk, I will present the results from an intensive helium triplet survey of TOI-6963b based on 5 transits observed with the 10m-class telescopes Keck/NIRSPEC and HET/HPF. The He I triplet line is a powerful tracer of extended and escaping atmospheres, enabling us to investigate whether atmospheric mass loss is already underway. Moreover, He I line modeling enables us to place direct constraints on the geometry and dynamics of the atmospheric outflows, and how it is influenced by the extreme stellar irradiation and the disk dispersion environment. The repeated transit observations allow us to assess the robustness and variability of the signal in such an active young system. To disentangle planetary atmospheric signatures from stellar effects, we conducted a simultaneous observational campaign combining high-resolution spectroscopy and photometric monitoring. This multi-facility campaign represents one of the most comprehensive helium datasets obtained for a single young exoplanet.

I will present and interpret the He I triplet results in the context of hydrodynamical escape models, considering their implications for planetary evolution and formation. These observations provide new constraints on the timing and efficiency of atmospheric mass loss, testing whether photoevaporation can operate efficiently during disk dispersal or whether other processes dominate at such early epochs. Ultimately, I will place TOI-6963b within the broader context of young and mature exoplanet populations, highlighting how observations of this system provide critical constraints on the timing and efficiency of atmospheric mass loss and its impact on shaping planetary demographics."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

TRACING CLOUD CONDENSATION AND FORMATION HISTORIES ACROSS THE GIANT PLANET POPULATION WITH OBSERVATIONS OF SILICON CHEMISTRY

Luke Parker
University of Oxford

"Refractory material (e.g. silicon) is a key component of exoplanet chemistry and governs the formation of clouds, which shape the evolution of the giant planet population. However, most atmospheric studies to date measure only volatile species in exoplanet atmospheres leaving the exact nature of cloud species forming on hot giant planets uncertain. Different silicate condensates (e.g. MgSiO3 (enstatite) or SiO2 (quartz)) sequester different amounts of oxygen and metals, thus biasing inferred C/O and metallicity measurements from all observed spectra. Therefore, observations of the refractory content of exoplanet atmospheres are critical to understand cloud formation. Unlike in ultra-hot Jupiters, where refractories exist as atoms and ions, refractory species in directly imaged planets are locked up in molecules, making them challenging to detect. Fortunately, high-resolution spectroscopy (HRS) in the mid-infrared M-band provides unique access to refractory silicon through gaseous SiO at 4 microns.

Here, I will present the results of the CRIMSON survey of silicon chemistry in the directly imaged planet population with CRIRES+ M-band (3.5 – 5.3 microns). We observe six targets spanning the 1200 – 2200 K temperature range, detecting SiO and measuring its abundance to 0.5 dex precision with atmospheric retrievals. The measured SiO abundance traces the decline in gas phase silicon with the planetary atmospheric temperature, directly probing sequestration of the gaseous SiO into (magnesium-)silicate cloud decks. By precisely measuring this depletion of gas phase silicon and oxygen bearing species across the population we can, for the first time, estimate the exact composition of the cloud species forming on directly imaged planets (e.g. Mg2SiO4 vs. MgSiO3 vs. SiO2). This provides a direct test of opposing theories of cloud formation and will help determine whether sedimentation and rainout drive condensation, or whether cloud seed particles form deep in the atmosphere and are transported upward. Furthermore, measurements of the atmospheric refractory-to-volatile ratios offer new opportunities to infer planetary formation scenarios, breaking existing degeneracies in the use of the C/O ratio, and we constrain whether each of our targets formed through core accretion or gravitational instability. These results are a pathfinder for the LM-band high resolution spectrograph METIS/ELT (first light in 2029). As the first widespread use of the M-band for HRS, these results provide a preview of the atmospheric characterisation that will be performed at ELT first light."

MULTI-EPOCH ATMOSPHERIC VARIABILITY OF PSO J318: THE FIRST TEST CASE IN A LATITUDE-DEPENDENT STUDY

Danya Alboslani &
Y. Zhou (1); N. Fuda (2); D. Apai (2); B.E. Miles (2)
(1) University of Virginia; (2) University of Arizona

"Observational and modeling studies indicate that the atmospheres of directly imaged exoplanets and brown dwarfs could be spectroscopically distinct as a function of latitude. The mechanisms behind this are uncertain however, a compelling hypothesis to explain the phenomena is latitudinal dependent atmospheric circulation. While the equator and mid-latitude regions feature zonal circulations, the poles might be vortex-dominated, leading to differences on the appearance of spectra and photometry at short and long timescales.
We are undertaking the first JWST NIRSpec multi-epoch time-resolved observations of three planetary mass objects with ultracool atmospheres, each at different inclination angles test this hypothesis. We present the observations for the free-floating exoplanet PSO J318 at three epochs over the span of 82 rotational periods, providing snapshots of its highly dynamical atmosphere. Preliminary results reveal variability over the object's rotational period and on multi-epoch timescales. We present the light curves of this object from 1.7-2.06 um as well as isolated methane, water, and carbon monoxide features as a function of time. These observations provide exciting direct constraints on the 3D cloud structures and chemical processes in giant exoplanet atmospheres."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

A JWST/NIRSPEC PHASE CURVE OF THE ULTRA-SHORT PERIOD ROCKY PLANET K2-141 B

Gavin Wang &
Néstor Espinoza, Amélie Gressier
Johns Hopkins University, Space Telescope Science Institute

Determining interior compositions is essential for a holistic understanding of rocky exoplanets. However, this task remains a major hurdle. Interiors cannot be directly probed, and inferences based on bulk density alone are highly degenerate. A subclass of rocky planets called ultra-short period (USP) planets offers a tantalizing solution to this problem. With equilibrium temperatures exceeding 2000 K, these planets are hot enough to vaporize rock, theoretically generating mineral atmospheres that directly reflect their interior abundances. We focus on K2-141 b, a USP orbiting a K dwarf every 6.7 hours. Previous Spitzer observations of this planet hinted at a tenuous atmosphere but could not conclusively rule out a more substantial one. Here we present a JWST/NIRSpec thermal phase curve of this planet including two secondary eclipses. Our analysis of these ultra-precise measurements suggests the planet has a substantial atmosphere or a highly reflective surface, with weathering making the latter scenario unlikely. These findings indicate that USPs might cover a unique part of the parameter space when it comes to searches for atmospheres around rocky worlds, allowing us to peer into their interiors — which might in turn provide unique insights to understand rocky exoplanets as a population.

PLATO SPECIAL SESSION

THE PLATO MISSION

Heike Rauer
Freie Universität Berlin and DLR, Berlin

PLATO (PLAnetary Transits and Oscillations of stars) is ESA's M3 mission and designed to detect and characterize extrasolar planets by high-precision, long-term photometric and asteroseismic monitoring of a large number of stars. PLATO will detect small planets around bright stars, including terrestrial planets in the habitable zone of solar-like stars. With asteroseismology of their host stars and complementary radial velocity observation from ground-based telescopes, planets will be characterized for their radius, mass, and age with high accuracy. PLATO will provide us the first large-scale catalogue of well-characterized small planets up to intermediate orbital periods, relevant for a meaningful comparison to planet formation theories and to better understand planet evolution.
PLATO is scheduled for a launch date in Q1 2027. Today, in 2026, the payload including 26 wide-angle cameras with 12cm aperture each is integrated on the satellite platform and final spacecraft and ground-segment tests are ongoing. This presentation will give an overview of the PLATO mission and its current development status.

PLATO SPECIAL SESSION

PLATO STATUS AND PLANNED DATA RELEASES

Ana Heras
European Space Agency

The PLATO spacecraft is designed to perform high-precision photometry of more than 150,000 bright, Sun-like stars simultaneously. The payload consists of 24 “normal” cameras and 2 “fast” cameras, covering a field of view of approximately 2100 deg^2. This configuration will achieve a noise-to-signal ratio of 50 ppm in one hour for a G0V star with V = 11. The current observing strategy involves pointing to two sky fields for a duration of two years each. This strategy will be reassessed when the in-orbit performance is known. The first sky field that will be observed with PLATO, LOPS2, is in the southern Galactic hemisphere. Raw, calibrated, and science data products for the stars in the PLATO stellar samples will be publicly available following an established data release scheme.

PLATO is planned for launch in early 2027 and will operate in a large-amplitude orbit around the Sun–Earth L2 point. The satellite is currently undergoing integration and verification activities and has completed the vibration, acoustic, and thermal-vacuum tests.

PLATO SPECIAL SESSION

THE PLATO GUEST OBSERVERS PROGRAMME

Maximilian Guenther

The PLATO Guest Observers (GO) Programme enables the worldwide community to participate in the mission by proposing observations beyond the core science objectives. These proposals may span a broad range of complementary science, from Solar System bodies to extragalactic transients, within the predefined observing field. A dedicated 8% fraction of the nominal mission's telemetry is allocated to support this. The 1st Announcement of Opportunity (AO-1 Call) opened on 7 April and closed on 21 May 2026, attracting strong interest from the community. This talk will outline the structure of the GO Programme, examples of possible observations, the proposal process, the review framework, and early statistics of the AO-1 Call. It highlights how the GO Programme further expands PLATO's scientific return while fostering community-driven discovery.

PLATO SPECIAL SESSION

THE PLATO INPUT CATALOG

Giampaolo Piotto
Dipartimento di Fisica e Astronomia

Because of its large observing field (more than 2100 square degrees, almost 0.7 square meters of CCDs), PLATO full frame images cannot be down-loaded to ground. Therefore, PLATO mission had to prepare a PLATO Input Catalog (PIC), containing the targets for exoplanet search (tPIC).
In this talk we will mainly present the adopted methodology for the tPIC target selection (mainly FGK dwarfs and subgiants fainter than V=13, and M dwarfs fainter than V=16), following the mission requirements for the maximization of small exoplanet in habitable zone yield. The content of the tPIC, that will also include stars hosting confirmed and candidate exoplanets, will be presented and analyzed.
The final PIC is a merge of five subPICs: the tPIC, the stellar astrophysics calibration and verification targets (scvPIC), the fine guidance stars (fgPIC), and the instrument calibration targets (cPIC). In the talk we will briefly describe the integration of these subPICs into the final PIC.
The metrics used to select a subsample of the targets (15,000 stars), the prime sample, for which the mission is committed to guarantee ground-based follow-up for exoplanet confirmation and mass measurement will also be described, and prime sample star properties will be discussed.

PLATO SPECIAL SESSION

THE PLATO EXOPLANET SCIENCE

Don Pollacco

We will look at the range of exoplanet science that plato data is expected to contribute to. This includes studies of demographics as a function of insulation and system age - relationships that have so far only been poorly studied. Comparison of these will be used to test statistically based planetary evolutionary models.

PLATO SPECIAL SESSION

THE PLATO STELLAR SCIENCE

Jordan Philidet

The primary target (or Core Programme) of the PLATO mission consists of a large sample of about 250,000 main-sequence and subgiant stars. Through the high-precision, long-term photometric monitoring of these stars, combined – for at least the 15,000 brightest among them – with their thorough asteroseismic analysis, the instrument was designed to fulfil several scientific goals. For stellar science, these are two-fold: 1) to determine the radius, mass, and age of an unprecedented number of stars with a precision and accuracy never-before reached, and 2) to provide observational constraints strong enough to test important aspects of the modelling of stellar interiors and their dynamics, which constitutes the current bottleneck of state-of-the-art stellar evolution models.

This presentation will give an overview of the expected outcome of the PLATO mission for stellar science, with a focus on the expected asteroseismic yield (on which hinges the precise characterisation of exoplanetary host stars, and therefore exoplanets themselves), as well as the stellar science questions that the PLATO data will enable us to tackle.

PLATO SPECIAL SESSION

THE GROUNDBASED OBSERVING PROGRAM

Stéphane Udry

exo 6

EXOPLANETS
PORTO
2026

CONFERENCE ABSTRACTS E-BOOK

THURSDAY, JULY 02

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

BIOSIGNATURE DETECTION AND INTERPRETATION: CHALLENGES AND PATHWAYS

Daniel Apai
University of Arizona

The detection and correct interpretation of biosignatures in extrasolar planets is emerging as one of the most compelling goals of modern astrophysics and astrobiology. This goal motivates the work of thousands of scientists and engineers worldwide and is supported by major investments from governments and science philanthropy. With exciting and rapid progress in exoplanet discovery, characterization, theory, and enabling technologies, the future of this field has never been brighter. At the same time, the potential complexity of habitable planets and their systems may be vast, while the quality and quantity of obtainable data will be limited. It is important that, as we formulate some of humanity's most inspiring scientific experiments, we do so with a thorough understanding of the challenges against which these experiments must be robust. In this talk, I will review the key challenges in biosignature detection and interpretation in the context of the exciting opportunities provided by upcoming and future observational capabilities. Finally, I will address potential pathways toward overcoming these challenges.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

SMALL-SCALE STELLAR MAGNETISM AS A SYSTEMATIC IN EXOPLANET TRANSITS: LIMB DARKENING AND INGRESS–EGRESS ASYMMETRIES

Nadiia Kostogryz
Max Planck Institute for Solar System Research

"Accurate exoplanet radii and atmospheric inferences from transit spectroscopy depend on reliable stellar limb-darkening models. However, high-precision light curves from Kepler, TESS, and JWST increasingly suggest that many stars are brighter near the limb than predicted by standard nonmagnetic atmospheres, introducing a growing systematic in transit analyses. Here we show that small-scale surface magnetism provides a natural explanation and can also generate ingress–egress asymmetries that may be misinterpreted as planetary day–night (morning–evening) contrasts.

We compute centre-to-limb intensity profiles using 3D radiative magnetohydrodynamic simulations with the state-of-the-art MURaM code, combined with ray-by-ray spectral synthesis using MPS-ATLAS, for a grid of stellar models spanning F3–M4 spectral types, multiple metallicities, and a range of surface magnetizations. We find that magnetic flux concentrations make limb darkening systematically shallower via two coupled effects: (1) they modify the photospheric stratification, changing the temperature structure that sets the centre-to-limb intensity variation, and (2) they corrugate the visible surface and increase the contribution of bright "hot walls" of magnetically evacuated structures, which become more prominent toward the limb. Including surface magnetism reconciles models and observations.

Beyond symmetric limb darkening, we show that spatial variations in magnetization across the stellar disk can produce limb-brightness asymmetries that imprint measurable differences between transit ingress and egress. For solar-like hosts, ingress–egress depth differences can reach ≈600 ppm for a 10,000 ppm transit at 0.6 μm, depending on the magnetization contrast between the stellar limbs—comparable to planetary signals. Because such magnetic concentrations can occur without spots and with minimal photometric variability, even apparently quiet stars may exhibit this effect. We quantify how these magnetic effects vary with stellar parameters, metallicity, and wavelength, and show how their distinct spectral signatures can separate stellar from planetary signals in precision transit data."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

SUB-KELVIN TEMPERATURE TIME SERIES OF THE SUN OVER 10 YEARS WITH HARPS-N

Charles Cadieux &
Xavier Dumusque (1), Jean-Baptiste Delisle (1), Michael Cretignier (2), Khaled Al Moulla (3), Sara Tavella (1)
(1) Geneva Observatory, (2) University of Oxford, (3) IA Porto

Since 2015, the HARPS-N solar telescope has delivered over 100,000 Sun-as-a-star spectra at sub-m/s radial velocity precision, providing an unprecedented view of solar variability. Using a novel line-by-line differential temperature indicator (dTemp) derived spectroscopically, we achieve sub-Kelvin sensitivity over a decade of HARPS-N observations. During the peak of magnetic activity, the temperature time series is well described (~90% of the variance) by a linear combination of covering fractions of active regions (faculae and spots) and quiet photospheric radial velocity derived from Solar Dynamics Observatory (SDO) observables. We demonstrate that dTemp can serve as a proxy of photometry simultaneously to the RV to trace super-granulation, rotation, and magnetic cycle modulations. We apply the FENRIR framework, a physics-based model of stellar activity to jointly model the RV and dTemp with a multidimensional GP. This modeling using dTemp as an anchor of solar magnetic activity leaves RV residuals at the 40 cm/s over 10 years. This proof of concept establishes a powerful pathway toward mitigating stellar activity and ultimately enabling the detection of true Earth analogs at the 10 cm/s level.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

THE STAR IS THE SIGNAL: TAMING STELLAR ACTIVITY FOR EXOPLANET DETECTION AND CHARACTERISATION

Ignasi Ribas
Institute of Space Sciences (ICE, CSIC) & IEEC

Extreme-precision radial velocity (RV) instruments (e.g. ESPRESSO), delivering long-term stability at the 10 cm s^{-1} level, and space telescopes (e.g. JWST), achieving relative flux uncertainties of order 10 ppm, are now a reality. At least in principle, this level of precision is sufficient to enable the discovery and characterisation of small rocky planets, including true Sun–Earth analogues. However, intrinsic stellar variability can overwhelm instrumental errors and become the dominant source of uncertainty, even for relatively quiet stars such as the Sun. In this talk, I will illustrate the impact of stellar activity on planet detection and characterisation, and present and compare different efforts in the community to mitigate its effects in both radial velocities and transmission spectroscopy. I will particularly discuss data-driven and physics-driven approaches, and present our work exploiting the unique combination of physical modelling and contemporaneous multi-technique observations to obtain an accurate description of the stellar active surface. I will showcase recent results and demonstrate levels of performance that increasingly bring the detection and atmospheric characterisation of temperate rocky planets, including true exo-Earths, within reach.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

POET: LOOKING AT THE SUN, FINDING OTHER EARTHS

Nuno Santos &
PoET Team
Instituto de Astrofísica e Ciências do Espaço/U. Porto

"The detection and characterization of Earth-like planets—those with physical conditions suitable for liquid water and potentially life-sustaining environments—is a major goal of modern astrophysics. However, this search is significantly hindered by astrophysical ""noise"" from host stars, which distorts the spectra used to detect and analyze these planets. Current methods to mitigate this issue have not yet achieved the necessary level of precision.
The Paranal solar Espresso Telescope (PoET) aims to offer a novel approach to understanding stellar ""noise"". Expected to begin observations in April 2026, PoET will be connected to the ESPRESSO spectrograph on the ESO-VLT. It will provide both disk-resolved and disk-integrated (""Sun-as-a-star"") observations of the Sun. This unique dataset, obtained in ultra-high resolution mode (R > 200,000), will cover the full optical spectrum (380–780 nm) in a single observation. By using the Sun as a proxy for other solar-type stars, PoET will allow for detailed mapping of our star, enabling an unprecedented understanding of how different solar features contribute to spectral variability. This, in turn, will inform the best strategies for mitigating stellar ""noise"" in exoplanet research.
In this talk, I will present an overview of the PoET project, its science goals, the organisation of the science team, as well as its first results."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

THE CURIOUS ORBITS OF ECCENTRIC WARM JUPITERS

Diego Munoz
Northern Arizona University

Spin–orbit misalignment measurements can encode valuable clues about the internal structure of stars. The latest generation of high-resolution spectrographs has enabled spin–orbit measurements for planets on increasingly long-period orbits. A striking and unexpected pattern has emerged: warm Jupiters (WJs) (orbital periods between 10 and 200 days) are overwhelmingly well aligned with the spins of their host stars. This behavior stands in sharp contrast to the hot Jupiter population (periods < 10 days), which exhibits a wide and often extreme distribution of stellar obliquities. Even more puzzling, this alignment among WJs persists despite many of these planets occupying highly eccentric orbits, directly challenging theoretical expectations that link large eccentricities with large inclinations. In this talk, I will discuss quantitative scenarios capable of explaining these systems, including novel formation channels such as coplanar high-eccentricity migration and the role of non-conventional tidal mechanisms. In particular, I will show how the dissipation of inertial waves in stellar convective envelopes can realign stellar spins without altering orbital eccentricities or semi-major axes—allowing obliquity damping without orbital decay or circularization. This effect may be especially efficient during the brief pre-main-sequence phase, when stars are larger, rapidly rotating, and fully convective. These findings reshape our understanding of warm Jupiter evolution and point to the need for a fundamental reassessment of tidal dissipation processes in star–planet interactions.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

STELLAR [O/SI] ENHANCEMENT IS A PREDICTOR OF GIANT PLANETS

Jared Kolecki
University of Notre Dame

Planet formation is not purely a physical process; it is a chemical process as well. The elemental abundances of host stars provide critical clues about the conditions that were present in their protoplanetary disks. Of particular interest is the oxygen to silicon ratio, [O/Si]. Both elements play an important role in shaping the mineralogy and volatile element chemistry of the disk. We homogeneously analyzed the elemental abundances of 534 stars with Keck-HIRES spectra from the Kepler Giant Planet Search (KGPS) and the California Legacy Survey (CLS). These stars all have significant radial velocity measurement baselines that yield good sensitivity to giant planets at long orbital periods. After correcting for cosmochemical trends, we find that the [O/Si] abundance ratio in giant planet host stars (with M_p > 0.2M_J or R_p > 0.6R_J) is 0.07 dex higher on average than in stars without giant planets. This distinction persists in both samples with high significance (p < 0.05 for 17 giant hosts, 37 non-giant hosts in KGPS; p < 0.01 for 84 giant hosts, 21 non-giant hosts in CLS). Our result suggests that disks that are enriched in oxygen could lead to elevated giant planet occurrences. This may be the first chemical evidence supporting the long-standing theory that accumulation of solid-phase water (H2O) beyond the ice line is critical for giant planet growth.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

RESPONSES OF EXOPLANET ATMOSPHERES TO STELLAR FLARES AND VARIABILITY

Jean-Michel Desert
Institut für Astrophysik Potsdam- AIP

"The atmospheric properties of exoplanets are strongly shaped by the high-energy radiation and particle environments of their host stars. On short timescales, stellar flares, rotational variability, and coronal mass ejections (CMEs) can induce rapid and significant perturbations in atmospheric structure, chemistry, and escape processes. Sudden enhancements in X-ray and ultraviolet flux during flares drive transient photochemical responses, increasing ionization, heating the upper atmosphere, and altering the abundances of key species such as hydrogen, molecules and ions. These effects can enhance atmospheric mass loss and modify observable spectral signatures on timescales of minutes to days.
We present JWST and ground-based time-series observations that provide compelling evidence for quasi-instantaneous atmospheric responses to stellar activity. We discuss the implications for atmospheric detectability and inferred atmospheric properties, including photochemistry, composition, and dynamics and the implications for the time lags of the atmospheric responses. We report observations of both young and mature exoplanets exhibiting atmospheric variability linked to transient stellar processes, and we examine the consequences of such variability for early and long-term atmospheric evolution. We emphasize that time-resolved, multi-wavelength observations, combined with time-dependent atmospheric modeling, are essential for disentangling stellar-driven variability from intrinsic atmospheric processes and for enabling robust interpretation of exoplanet atmospheric measurements."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

AN OVERVIEW AND EARLY PERFORMANCE UPDATE OF NASA'S PANDORA SMALLSAT MISSION TO CHARACTERIZE EXOPLANETS AND THEIR HOST STARS

Ben Hord &
Elisa V. Quintana (1); Jessie L. Dotson (2); Knicole D. Colón (1); Dániel Apai (3); Thomas Barclay (1); Trevor O. Foote (1); Emily A. Gilbert (4); Christina Hedges (1); Rae Holcomb (1); Aishwarya Iyer (1); Jordan Karburn (5); Benjamin V. Rackham (6); Jason F. Rowe (7); Pete Supsinskas (5)

(1) NASA Goddard Space Flight Center; (2) NASA Ames Research Center; (3) University of Arizona; (4) California Institute of Technology/IPAC; (5) Lawrence Livermore National Laboratory; (6) Massachusetts Institute of Technology; (7) Bishop's University

NASA's Pandora SmallSat launched in January 2026 with the goal of disentangling stellar activity from planetary atmospheric signatures in transmission spectroscopy observations. Although a powerful tool for probing planetary atmospheres, high-precision transmission spectroscopy measurements are easily contaminated by star spots and faculae, potentially making the origin of spectral features ambiguous. Pandora is designed to address this stellar contamination issue by observing exoplanet hosts via simultaneous long-duration, visible-light photometric and near-IR spectral observations. The simultaneous multiwavelength observations from Pandora constrain spot covering fractions on exoplanet host stars, allowing for the disentangling of star and planet signals in transmission spectra to more reliably determine planetary atmosphere compositions. Post-launch, Pandora underwent a month-long commissioning period in which spacecraft functionality was tested and initial performance of the observatory was assessed. Key benchmarks such as thermal stability, detector noise, pointing accuracy, and photometric precision were evaluated and validated through a suite of commissioning activities meant to provide baseline knowledge for the spacecraft's primary mission and auxiliary science program. These activities were both meant to mimic normal operations as well as exercise additional observing modes of potential use to scientific observations. The results of Pandora's commissioning are now publicly available and can be used for planning observations with the telescope or analyzing Pandora's data, all of which is available with no proprietary period. This presentation will provide an introduction and overview of the Pandora mission as well as a description of the observatory's commissioning activities and early performance, which are both vital to those that wish to utilize Pandora's data or plan observations.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

CONNECTING THE ATMOSPHERES OF THE COLDEST WORLDS AND HOTTEST PLANETS

Emily Calamari &
Jacqueline K. Faherty (1), Channon Visscher (2), Marina Gemma (1), Austin Rothermich (1,3), Francisco Ardevol Martinez (1), Sherelyn Alejandro Merchan (1,3), Genaro Suarez (1), Niall Whiteford (1)
American Museum of Natural History; (1) American Museum of Natural History, (2) Dordt University, (3) CUNY Graduate Center

In the era of JWST, it is now possible to look into substellar atmospheres in unparalleled detail and precision. With exquisite JWST NIRSpec or MIRI data in hand, atmospheric retrievals are a leading data-driven tool that can recover an extrasolar world's fundamental parameters such as mass, radius, effective temperature, gravity, cloud structure and chemical abundances. However, there is one clear atmospheric phenomenon that confounds all modeling attempts: the overall impact of clouds on observational properties. To break model degeneracies largely brought on by issues with clouds, several works have shown the power that main sequence star–brown dwarf companion systems have when the host star can anchor metallicity, age, and abundance measurements for its substellar companion. In this work, we bring together insight from brown dwarf atmospheric theory and our own Solar system to recently published giant exoplanet analyses. We will show the results of a re-examination of the retrievals for HD 189733 b, WASP-107 b, WASP-17 b and WASP-39 b – four JWST-observed Hot Jupiters – using host star abundances for context. We ground our re-analyses using the respective host star chemistry to benchmark the retrieved chemistry and silicate cloud solutions (i.e. enstatite; MgSiO_3, forsterite; Mg_2SiO_4, and/or quartz; SiO_2). In applying analytical techniques used in companion brown dwarf studies, we find confirmation that giant exoplanets form and accrete in the outer protoplanetary disk, thus inheriting their host star Mg/Si ratio. This talk aims to discuss this work in detail and highlight the importance that brown dwarf literature plays in understanding giant exoplanet formation and evolution.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

KNOW THY STAR, KNOW THY PLANET: PROBING TRANSIT LIGHT SOURCE EFFECTS IN AN ACTIVE LATE K-STAR

Vigneshwaran Krishnamurthy &
Charles Cadieux (2), Mahesh Herath (1), Jared Splinter (1), Dhvani Doshi (1), Louis-Philippe Coulombe (2), Nicolas Cowan (1), Rene Doyon (2), Vincent Yariv (3)

Trottier Space Institute, McGill University; (1) Trottier Space Institute, McGill University, (2) Trottier Institute for Research on Exoplanets, University of Montreal, (3) University Grenoble Alpes

Cool stars are intrinsically active and heterogeneous, and their surface inhomogeneities can imprint signals on transit spectra that mimic or obscure planetary atmospheric features. This contamination, known as the Transit Light Source Effect (TLSE), poses a major challenge for atmospheric characterization, particularly in systems observed with the precision of JWST. Robust interpretation of exoplanet spectra therefore requires a detailed understanding of the host star. Here, we present JWST observations of multiple near-sequential transits of a late K-type star hosting five transiting planets. Several of these planets share similar transit chords across the stellar disk, enabling a direct probe of stellar surface heterogeneity through comparative transit analysis. The availability of both small, likely rocky planets and a larger sub-Neptune in the same system offers a unique opportunity: transits of the rocky planets can be used to constrain TLSE and stellar contamination, which can then be applied to isolate the atmospheric signal of the sub-Neptune. This approach provides a powerful framework for disentangling stellar and planetary signals in active multi-planet systems and demonstrates how stellar heterogeneity can be leveraged, rather than avoided, to improve atmospheric characterization. The method is broadly applicable to the growing population of compact multi-planet systems orbiting cool stars.

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

DISENTANGLING STELLAR ACTIVITY IN HIGH-PRECISION EXOPLANET TRANSMISSION SPECTROSCOPY

Giuseppe Morello &
Ariel – Activity Correction for Planetary Spectra working group
IAA CSIC

"Transmission spectroscopy is a cornerstone for probing exoplanet atmospheres. However, numerous studies have shown that stellar activity can subtly bias the inferred atmospheric properties. Stellar spots and faculae can induce spectral slopes that are degenerate with haze and cloud signals, and in some cases can even mimic molecular absorption features, such as H_2O in planets transiting M dwarfs. As observational precision improves, the impact of stellar signals becomes increasingly significant across a widespread sample, highlighting the need for the development of robust mitigation strategies.
In this talk, we present a multi-pronged approach developed within the Ariel Science Consortium to correct for stellar activity signals in exoplanet transmission spectra.
We compare and combine methods that either apply prior corrections, using the same data or ancillary observations, or integrate stellar signal modelling directly within atmospheric retrievals. This approach has been validated on a curated set of simulated data, consistently modelling high- and low-resolution spectroscopy as well as photometry across multiple instruments, making it likely the most thorough benchmark for stellar activity correction methods in exoplanet observations.
Furthermore, preliminary tests on JWST and follow-up data confirm the internal consistency of the adopted methods on real observations, demonstrating their potential for broader application to state-of-the-art high-precision datasets."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

THE INFLUENCE OF STELLAR SPECTRAL LIBRARIES ON TRANSMISSION SPECTRA

Nina-Elisabeth Nemec &
Òscar Porqueras-Leon (1,2), Ignasi Ribas (1,2), Alexander I. Shapiro (3,4)
ICE-CSIC, Barcelona; 1 – ICE-CSIC (Barcelona), 2. IEEC (Barcelona), 3. Karl-Franzens Universität (Graz), 4. Max Plack Institute for Solar System Research (Göttingen)

"Stellar activity contamination in planetary transmission spectra is currently the crux, prohibiting reliable extraction of atmospheres of small rocky planets. Physics-based forward models of stellar activity models generally really on two building blocks: The distribution of magnetic features (such as spots and faculae) on stellar discs and their corresponding intensity spectra. The surface distribution of other stars generally is unknown, with the exception of our very own star, the Sun. We therefore investigate the solar paradigm as 'ground truth' to explore how much the chromatic effects depends on the distribution of magnetic features. In particular, we explored the impact of centre-to-limb variations (CLV) of the magnetic features and their resulting chromatic effect. For this, we compared several well-used methods of construction in particular faculae spectra and compare such calculations to first-principle physic faculae spectra obtained with the 3D MHD MURaM code.

We present an analysis of error-propagation on the retrieved planetary radius, stemming from both the degeneracy in the distribution of the magnetic features, but also the treatment of particular the faculae component to the variability. We further explore the possibilities of breaking the degeneracies of the surface distribution of magnetic features by using information extracted from multi-wavelength photometry and spectra indicators to characterize the stellar variability."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

CHALLENGING EXOPLANET ATMOSPHERIC DETECTIONS WITH 3D NON-LTE STELLAR SPECTRA

Gloria Canocchi
Stockholm University/IAC

"High-resolution transmission spectroscopy from ground-based facilities has become a powerful tool for characterizing the atmospheres of close-in exoplanets. However, the interpretation of these observations critically depends on an accurate treatment of stellar effects arising during transit, most notably the center-to-limb variation (CLV) and the Rossiter–McLaughlin (RM) effect. If not properly accounted for, these effects can mimic, distort, or even suppress planetary absorption signals, leading to biased inferences of atmospheric composition and structure.

Most current corrections rely on 1D plane-parallel LTE stellar atmosphere models, which are known to fail in reproducing spatially resolved observations of the solar disk. In contrast, state-of-the-art three-dimensional radiation-hydrodynamic models combined with non-local thermodynamic equilibrium (3D non-LTE) line formation provide a physically consistent description of stellar line profiles and their variation across the stellar surface (i.e., their CLV).

The first application of 3D non-LTE stellar spectra to the Na I D lines in high-resolution transmission spectra has recently demonstrated that these advanced models are required for a more detailed and physically accurate characterization of exoplanetary atmospheres. In particular, for the benchmark exoplanet HD 209458b, the 3D non-LTE stellar models are able to explain the spectral features of the Na I D lines in the observed transmission spectrum without the need for any planetary absorption, thereby robustly confirming the Na non-detection suggested in previous works.

Building on these results, this talk extends the 3D non-LTE spectrum synthesis beyond sodium to other key atomic species commonly targeted in transmission spectroscopy, such as K, Mg, Ca, and O, for which strong 3D and non-LTE effects are likewise expected. I will present new results based on ESPRESSO observations of giant exoplanets, showing how realistic 3D non-LTE stellar models can significantly improve the modeling of the CLV and RM effects and, in turn, the interpretation of exoplanet atmospheric signatures.

These findings highlight the importance of using realistic 3D non-LTE radiative transfer for modelling stellar spectra to correct for stellar contamination in high-resolution observations of exoplanet atmospheres. These kinds of studies will be fundamental to fully exploit the capabilities of next-generation instruments, such as ANDES at the Extremely Large Telescope."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

GRANULATION-DRIVEN RADIAL VELOCITY VARIABILITY: FIRST RESULTS FROM POET

Carmen San Nicolas Martinez &
N. C. Santos(1) (2); V. Adibekyan(1) (2); K. Al Moulla (1); A. M. Silva (1) (2); S. G. Sousa (1) (2)
(1) Institute of Astrophysics and Space Sciences; (2) University of Porto

"The detection and characterization of low-mass exoplanets with radial velocities (RVs) are increasingly limited by stellar surface processes, with granulation introducing short-timescale RV variability that can obscure planetary signals. A detailed, line-resolved understanding of granulation is therefore essential to improve activity mitigation strategies in the era of ultra-precise RV measurements.
In this contribution, I will present first results from the new PoET telescope, focusing on granulation-driven RV signals measured in disk-resolved solar observations. These data will represent some of the earliest scientific results from PoET and provide a unique benchmark to study stellar noise at its physical origin.
The analysis is performed using TILARA (Template-Independent Line-by-line Algorithm for Radial velocity Analysis), a line-by-line RV extraction code based on iterative multi-Gaussian fitting of individual absorption lines, without relying on spectral templates. By allowing full control over individual line selection and weighting, TILARA enables a direct exploration of how different spectral lines contribute to RV variability induced by granulation.
I will present a first preliminary classification of spectral lines according to their sensitivity to granulation, identifying both highly affected and comparatively stable lines. These early results demonstrate how disk-resolved solar observations can inform line selection strategies for unresolved stellar RV measurements, with direct implications for improving RV precision and robustness in exoplanet surveys.
This work provides a critical link between solar physics and exoplanet detection, contributing to the development of next-generation RV techniques required to detect and characterize Earth-like planets around Sun-like stars."

TOPIC 4: ASTROPHYSICAL CHALLENGES (DETAILED STELLAR CHARACTERISATION, STAR-PLANET CONNECTION, STELLAR NOISE)

NEW, SCALABLE EXTENSIONS OF CELERITE TO 2D DATA AND THEIR APPLICATIONS TO EXOPLANET SCIENCE

Mark Fortune &
Neale P. Gibson, Benjamin J. S. Pope
Macquarie University; Trinity College Dublin, Macquarie University

"Exoplanet science often requires analysing datasets with two or more dimensions, such as spectroscopic time-series, radial velocities with multiple stellar activity indicators, and imaging time-series. Additionally, Gaussian processes (GPs) have become a ubiquitous tool for dealing with correlated noise arising from both astrophysical and instrumental systematics. Despite this, existing optimisations of GPs – such as celerite – are largely restricted to 1D datasets. Although some extensions of celerite have been developed for 2D data, and are already in use within extreme precision radial velocity, these extensions come with limited flexibility, and still run slowly on larger datasets which are common within exoplanet atmospheres, such as spectroscopic time-series from JWST, or from ground-based high-resolution facilities. This limitation has made accounting for both time-correlated and wavelength-correlated noise simultaneously prohibitively expensive, with analyses of transiting exoplanet spectroscopy still typically analysed one light curve at a time, ignoring potential effects such as 1/f noise and stellar granulation, which are not independent for each light curve.
I will present new, exact optimisations which extend celerite to 2D data, which compared to existing extensions are both more flexible, and can achieve order of magnitude runtime improvements when run on large spectroscopic time-series from JWST containing millions of datapoints. For the first time, these extensions allow us to analyse JWST/NIRCam spectroscopic time-series at full time and wavelength resolution while simultaneously accounting for both wavelength-correlated 1/f readout noise, as well as time-correlated noise arising from stellar granulation, asteroseismology or instrumental systematics. These optimisations are key to pushing the limits of transiting exoplanet spectroscopy to smaller targets around bright host stars, as we increasingly hit noise floors from both readout noise and astrophysical sources which we must robustly model. I will present the results of applying this work to archival NIRCam eclipse observations of 55 CNC e, and describe how a full two-dimensional analysis of these data, as well as the effects of different reduction choices, affects the recovered emission spectrum covariance matrix and its atmospheric interpretation. These optimisations could see later applications to radial velocity analyses, where they may offer improved flexibility and runtime savings, and even to the analysis of high-resolution spectroscopic time-series, serving as a possible alternative to data cleaning algorithms such as PCA or SysRem."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

THE COOLEST PLANETS IN THE NEIGHBORHOOD: THE DIRECT DETECTION OF FRIGID ICE & GAS GIANTS ORBITING NEARBY SYSTEMS WITH JWST

Rachel Bowens-Rubin &
Aarynn L. Carter, Matson Garza, Samuel Hopper, Andrew Householder, Grant Kennedy, Mary Anne Limbach, James Mang, Elisabeth Matthews, Caroline V. Morley, Logan Pearce, Emily Pass, Maïssa Salama, Kevin B. Stevenson, Giovanni Strampelli, Andrew Vanderburg, Alex Venner, Kevin Wagner, Yifan Zhou

Eureka Scientific; Space Telescope Science Institute, MIT, UMich, UMich, University of Warwick, Umich, University of Texas Austin, Johns Hopkins APL, Max-Planck-Institut für Astronomie, University of Texas Austin, UMich, MIT, UC Santa Cruz, University of Edinburgh, Harvard University, Max-Planck-Institut für Astronomie, University of Arizona, University of Virginia

Cold giant planets similar to the giant planets in our solar system remain underrepresented in the known exoplanet population despite early hints that they are likely to be abundant. I will present results from two JWST direct imaging programs (GO 6122 & SURVEY 8581) that are opening this long-inaccessible discovery space using a newly developed strategy based on non-coronagraphic MIRI imaging at JWST's longest wavelengths (18–25 μm). Early observations demonstrate that this approach is capable of detecting a diverse population of giant planets outside their snow line that are colder than 200 K and span a wide range of cloud properties and metallicities. To date, more than a dozen candidates have been identified that are consistent with masses near the ice – gas giant boundary (0.05 – 0.3 Mjup), though future observations are required to determine if they are background objects or co-moving companions. These data provide a new avenue for independently measuring planet occurrence rates in a regime where radial velocity and microlensing surveys remain in tension. By observing up to 125 of our nearest stellar neighbors, these programs are establishing the coldest temperature limits yet accessible to direct imaging, even among JWST programs. Any planets confirmed through future observations would be prime targets for deep spectroscopic characterization and may forever be the nearest and brightest examples of their class.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

FROM DATA-DRIVEN TO PHYSICS-BASED: AN ALGORITHM FOR 2-10X IMPROVEMENT IN JWST EXOPLANET IMAGING SENSITIVITY

Rodrigo Ferrer Chavez
Northwestern University

"High-contrast exoplanet imaging has been historically restricted to the youngest, most massive and most widely separated giant planets. An important reason for this is the challenge of effective starlight removal: using image processing algorithms to subtract the stellar PSF and reveal faint planet signals. While the excellent IR capabilities of JWST have enabled imaging of lower mass and older planets (such as TWA 7 b, Eps Ind A b, and 14 Her c), its sensitivity is also severely reduced due to imperfect starlight removal algorithms. This loss in sensitivity is especially serious at close separations from the star, precisely where giant planets are most common.

A notable weakness of traditional algorithms is that they build a stellar PSF model from a combination of reference images (e.g. of other reference stars). This is a limitation because inevitable instrument systematics, such as thermal drifts, pointing errors and optical aberrations in the telescope, change from observation to observation. As a result, reference images are imperfect matches to our observation of interest and produce imperfect PSF models.

Here we present a new method for starlight subtraction and show its effectiveness in real JWST data, achieving superior sensitivity to traditional techniques in a variety of datasets. Unlike traditional methods, which are agnostic to the image formation process, we model the stellar PSF directly by simulating light propagation through the optical system. By using state-of-the-art optimization techniques from the machine learning community, we efficiently fit millions of free parameters in our model to produce the necessary fidelity for high-contrast imaging.

We show our method can recover known companions at 2-3x better signal-to-noise than published detections with standard techniques, and that we improve the sensitivity of existing exoplanet search surveys by up to an order of magnitude. We also confidently detect 51 Eridani b (one of the lowest mass imaged planets) at 4.3 micron for the first time, after a previously published non-detection with standard algorithms on the same dataset. This photometry measurement at the CO_2 absorption enables new atmospheric studies on this planet and a better understanding of its enhanced metallicity.

This method can extend the discovery and atmospheric characterization capabilities of all JWST observations to fainter lower mass (and older) giant planets at closer separations from their stars. Similarly, this technique can be extended to future facilities such as the Habitable Worlds Observatory, making the goal of directly imaging exo-Earths more feasible."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

A NOVEL BAYESIAN FRAMEWORK TO COMPUTE A DATASET'S SENSITIVITY TO TRANSITING PLANETS, WITH APPLICATIONS TO OCCURRENCE RATES.

Maddy Scott &
Amaury Triaud, Guy Davies
University of Birmingham; University of Birmingham

"Injection-recovery tests have traditionally been used to estimate detection limits in photometric datasets. Unfortunately they suffer from being computationally expensive and from being restricted to sparse, pre-defined parameter grids. In addition, one needs to subjectively decide what ""recovery"" means.
I will present a novel Bayesian inference framework which directly computes the posterior probability of a transiting planetary signature. This method can evaluate hundreds of thousands of model light curves, rejecting realisations that are inconsistent with data.
Compared to injection-recovery, our framework: 1) explores a continuous, high-resolution, multi-dimensional parameter space; 2) yields orders-of-magnitude more effective samples; and 3) achieves runtimes that are ~10-20x faster.
Thanks to its design, our framework enables a statistically coherent estimation of exoplanet occurrence rates. Because of its sensitivity to candidates, we can in principle measure planetary occurrence rates even in the absence of formal detections. This has important implications for PLATO's quest for Earth-twins."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

AUTOMATED EXPLORATION OF TESS ARCHIVAL DATA WITH DEEP LEARNING

Hugo Vivien &
Jana Baron [1], Magali Deleuil [1], Iliass Carega [1], Suzanne Aigrain [2], Nora Eisner [3]

Aix Marseille Univ, CNRS, CNES, Institut Origines, LAM, Marseille, France; [1]: Aix Marseille Univ, CNRS, CNES, Institut Origines, LAM, Marseille, France; [2]: University of Oxford, Oxford, United Kingdom; [3]: Department of Astrophysical Sciences, Princeton University, Princeton, NJ, 08544, USA

"Our ability to detect planet candidates in the transit method is currently strongly dependent on their orbital periods, leading to an observational bias towards short period planets. This bias stems from both the geometrical likelihood of transits, which decreases with orbital period, and our methodology which relies on prior filtering of the data and folding of the light curves to increase the signal to noise ratio of the signal.
We explore TESS archival data using the Panopticon deep learning model, originally designed to identify single transit events in unfiltered PLATO light curves. We train a new dedicated version of the model for TESS in an effort to systematize the search of single transits in the entirety of the TESS archive. This approach provides two key advantages; first, by bypassing the filtering step we avoid the risk of the transit being mistaken for stellar activity and being altered, or removed entirely. This effect is especially prevalent for longer period planets, due to the shallower and longer nature of the transit. Second, by training the model to detect single transits, we alleviate our reliance on the periodicity criterion.
Preliminary results show a recovery similar to that achieved on simulated PLATO light curves, with single transit events confidently recovered. On real data with injected planets, the model identifies upwards of 92% of the transits in the dataset (with a false positive rate of 0.39%), with cases with SNR<3 making the bulk of the missed transits. We also emphasize the practicality of this approach which can be trained in a matter of hours and is instantaneous in inference, whereas the filtering process is notoriously computationally expensive. We are currently expanding the test dataset by conducting the analysis of archival TESS sectors, to confirm our ability to detect long period planets reliably, and bolster the planet population in this regime. Furthermore, we will compare in depth the difference in capacity of this method with the current pipeline, by identifying its strength and weakness, and how it can complement current algorithms to provide the best possible search methods for exoplanet detection."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

EARLY-STAGE CLASSIFYING OF TESS LIGHT CURVES WITH MACHINE LEARNING

Marina Ventikos &
Vincent Van Eylen
University College London (UCL); University College London (UCL)

The detection of exoplanets in wide-field surveys like TESS is limited not only by the difficulty of spotting a transit-like signal, but also by astrophysical false positives and nearby flux contamination to the photometric aperture. Eclipsing binaries or blended background binaries and hierarchical systems can closely mimic planetary transit signals, complicating the process of validating exoplanet candidates, of which there are already thousands and quickly growing. Machine learning (ML) has already proven to be effective as a scalable and efficient vetting tool for transit survey data, but there is further scope to explore the potential of applying ML techniques in the earliest stages of the transit search. We present an ML framework for classifying stellar light curves, designed to be operational with flux time-series inputs prior to any periodic signal search, folding, or heavy pre-processing. Our approach uses convolutional neural network (CNN) architecture trained on a sample combining real and synthetic light curves. CNN architectures are particularly capable at feature/pattern recognition, making them ideal for the task of distinguishing between eclipse shapes and depths. Our synthetic sample of ~80,000 light curves is based on a detailed set of simulated astrophysical scenarios, including transiting planets and multiple types of on-target eclipses or blended false positives. The simulated events are injected into TESS light curves, thus inheriting real instrumental noise properties. To account for any overfitting from purely training on a highly controlled synthetic sample, we implement transfer learning to further train and fine-tune our classifier on real examples of confirmed exoplanets, eclipsing binaries, and blended scenarios vetted through follow-up programs in the TESS mission. To evaluate the design of our CNN architecture, we assessed its functionality when trained on a tiny sample of 1100 real TESS light curves. This trained model could confidently distinguish features between 3 classes: exoplanet, eclipsing binary, and companionless star, and correctly classify them with an accuracy of 89% on raw data and 92% on detrended data. This demonstrates the potential for higher performance with an enhanced training set, motivating the expansion to include the larger synthetic sample and more detailed false positive scenarios, particularly with CNN performance being highly correlated with training set size. Ongoing work is focused on scaling the architecture to handle more complex blended scenarios, as well as incorporating additional features to boost performance such as contextual/positional properties of neighbouring stars and stellar host properties. We aim for our framework to be useful as an early-stage vetting tool for large-scale transit surveys, with plans to adapt our framework for upcoming PLATO and ensure consistent performance across transit depth and noise regimes.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

A GROUND-BASED TRANSIT OBSERVATION OF THE LONG-PERIOD EXTREMELY LOW-DENSITY PLANET HIP 41378 F

Juliana Garcia-Mejia &
Zoë L. de Beurs, Patrick Tamburo, Andrew Vanderburg, David Charbonneau, Karen A. Collins, Khalid Barkaoui, Cristilyn N. Watkins, Chris Stockdale, Richard P. Schwarz, Raquel Forés-Toribio, Jose A. Muñoz, Giovanni Isopi, Franco Mallia, Aldo Zapparata, Adam Popowicz, Andrzej Brudny, Eric Agol, Munazza K. Alam, Zouhair Benkhaldoun, Jehin Emmanuel, Mourad Ghachoui, Michaël Gillon, Keith Horne, Enric Palle, Ramotholo Sefako, Avi Shporer, Mathilde Timmermans
Massachusetts Institute of Technology

We present a ground-based transit detection of HIP 41378 f, a long-period (P = 542 days), extremely low-density (0.09 ± 0.02 g/cm^3) giant exoplanet in a dynamically complex system. Using photometry from Tierras, TRAPPIST-North, and multiple LCOGT sites, we constrain the transit center time and use this detection, along with a recently published transit time from Rossiter-McLaughlin observations, to update the TTV solution for HIP 41378 f and predict future transit times to enable JWST observations. This marks only the second ground-based detection of this planet, currently the longest-period and longest-duration transiting exoplanet observed from the ground. Incorporating new TESS Sector 88 data, we rule out the 101-day orbital period alias for HIP 41378 d, finding that the remaining viable solutions are centered on the 278, 371, and 1113-day aliases. The latter two imply dynamical configurations that challenge the canonical view of planet e as the dominant perturber of planet f, suggesting that HIP 41378 d may instead play the leading role in shaping the TTV signal.

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

SIGNAL OR STOCHASTICITY? A HUMAN-VALIDATED DATASET FOR SINGLE-TRANSIT DETECTION

David Degen &
Florian Lienhard
ETH Zurich

"In recent years, TESS has continuously expanded the census of known exoplanets, greatly enhancing our understanding of these distant worlds. However, TESS is less efficient at detecting planets with orbital periods longer than about 15 days, as its observation strategy divides the sky into sectors, each of which is observed for only about 27 consecutive days, resulting in incomplete temporal coverage for planets with longer orbital periods. Planets with orbital periods exceeding the sector length are often observed only once (monotransits) or twice across sectors that are far apart in time (duotransits). This rarity of transits significantly reduces the effectiveness of traditional transit detection techniques, which work better the more transits are observed. In the low signal-to-noise ratio (S/N) range characteristic of such systems, machine learning (ML) approaches offer a promising alternative.

However, the sub-field of ML-driven single transit detection faces two fundamental challenges: the difficulty of curating high-quality training data at low S/N and the lack of standardized benchmark datasets for comparing proposed methods. Models trained exclusively on confirmed planets inevitably inherit historical detection biases, reinforcing sensitivity to signals similar to those already known. Injection-based training datasets do not suffer from this problem, but they come with the difficulty of identifying the limit of detectability a priori. Specifically, this refers to the difficulty of determining, without human involvement, whether an injection inserted into a light curve is detectable or remains irretrievably buried within correlated stellar and instrumental noise. Using a training dataset with a large proportion of non-recoverable examples generally degrades model performance, while an overabundance of trivial examples limits sensitivity near the detection threshold, which is precisely where it matters most for the search for small exoplanets.

In this talk, I present a curated dataset of TESS light curves with injected transit signals, constructed to enable direct and standardized comparison between machine-learning architectures as well as classical single-transit detection methods [Degen, D. et al. (2026), in preparation]. Crucially, the dataset is anchored to an empirical, human-based detectability limit, established by testing whether multiple trained humans can successfully recover each injected transit. Using this dataset, we evaluate different transit quality metrics, such as S/N accounting for red noise, by comparing them to the human classifications to assess how well they capture the context-dependent human-rated credibility of shallow transit signals. Metrics that accurately encapsulate what humans consider credible transits are of great interest, as they enable the creation of large high-quality training datasets bringing ML models closer to, and perhaps one day beyond, human-level performance in transit detection."

TOPIC 2: TOWARDS THE DETECTION OF THE LOWEST MASS/SMALLER PLANETS (METHODS, INSTRUMENTATION, DATA ANALYSIS)

A COMMUNITY EPRV DATA STANDARD

Jennifer Burt &
Andreas Quirrenbach, Andrew Howard, BJ Fulton, Cem Onyuksel, Chad Bender, Damien Ségransan, Emile Fontanet, Daniel M Krolikowski, Étienne Artigau, Gaspare lo Curto, Jonathan Crass, Julian Sturmer, Leonardo Paredes, Lily Zhao, Marshall Johnson, Martino Romaniello, Megan Bedell, Michelle Edwards, Neil Cook, Rose Gibson, Sam Halverson, Saskia Prins, Sarah Logsdon, Tanya Das, Timothy Pickering, Xavier Dumusque

Jet Propulsion Laboratory; University of Heidelberg, Caltech, NExScI, SAO, University of Arizona, University of Geneva, University of Geneva, University of Arizona, Université de Montréal, ESO, Ohio State University, University of Heidelberg, University of Arizona, University of Chicago, Ohio State University, ESO, Flatiron Institute, NoirLab/KPNO, Université de Montréal, UCLA, Jet Propulsion Laboratory, KU Leuven, NOIRLab, University of Chicago, MMTO/AstroPy/SALT, University of Geneva

Over the last five years, a new generation of EPRV spectrographs have come online, developed by teams around the globe. These instruments have implemented a variety of approaches in both their hardware and data reduction software designs and have now accumulated sufficient data volumes and observing baselines to investigate how specific differences in hardware (e.g., wavelength coverage, sampling, fibre scrambling techniques, etc.) and data processing (e.g., spectral extraction method, continuum normalization, wavelength calibration, etc.) flow down to impact the radial velocities obtained from each instrument. A standardized data format used across instruments can facilitate the cross-instrument comparisons necessary to reveal these impacts. We have just completed a global effort involving more than a dozen EPRV teams and observatories to establish such a standard and to develop 'translator' tools that can transform EPRV data products from their native formats to this community standard, and into formats relevant to stellar and exoplanet atmosphere focused science. This data standard can also provide a starting point for new instruments and reduce the burden of independently developing a data standard and pipeline. Here we will present the first release version of this data standard, introducing it to the broader spectroscopic community and provide templates for the data 'translators' to lay the groundwork for a coordinated comparison of stellar data between modern EPRV instruments. This effort also paves the way for multi-instrument EPRV observing campaigns and for developing a modular, open-source, EPRV analysis toolbox that will be compatible with a wide variety of current and future instruments.

DETECTION OF A LAVA WORLD ATMOSPHERE ON 55 CNC E

Engin Keles &
Ilya Ilyin2, Thomas Henning3, Lorenzo Pino4, Daniel Kitzmann5, Stefan Czesla6, Fabian Seidler7, Begüm Nisa Kasapli1, Lena Noack1, Enric Palle8, Ignas Snellen9, Katja Poppenhaeger2, Laura Kreidberg3, Caroline Brachmann1, Philipp Baumeister1, Anjali A. A. Piette10, Christiaan van Buchem9, Daniela Sicilia11, Luca Malavolta12, Matthias Mallonn2, Hamish Innes1, Paul Mollière3, Valerio Nascimbeni12, Yamila Miguel9, Klaus Strassmeier2

Freie Universität Berlin; 1. Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany 2. Leibniz Institut für Astrophysik Potsdam, An d. Sternwarte 16, 14482 Potsdam, Germany 3. Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany 4. INAF – Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi, 5, 50125 Firenze FI, Italy 5. Space Research & Planetary Sciences, University of Bern, Gesellschaftsstrasse 6, 3012 Bern 6. Thueringer Landessternwarte Tautenburg, Sternwarte 5, 07778 Tautenburg, Germany 7. ETH Zurich, Clausiusstrasse 25, 8092 Zurich, Switzerland 8. Instituto de Astrofísica de Canarias, C. Vía Láctea, 1, 38205 San Cristóbal de La Laguna, Santa Cruz de Tenerife, Spain 9. Leiden Observatory, Leiden University, Postbus 9513, 2300 RA Leiden, Netherlands 10. University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK 11. INAF – Osservatorio Astrofisico di Catania, Via S. Sofia, 78, 95123 Catania CT, Italy 12. INAF – Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio, 5, 35122 Padova PD, Italy

"Recent discoveries have confirmed the presence of rocky worlds in close orbits with high surface temperatures, enabling the surface rock to melt, a phenomenon known as lava worlds. For such planets, the preferred atmospheric scenario proposes a permanent magma ocean on the planet's surface, which builds up an extended, thin silicate-vapor atmosphere, with the properties of the latter defined by the composition of the former. One target of interest for deducing atmospheric conditions is the super-Earth 55 CNC e, which may possess a significant volatile dominated atmosphere, as inferred from one JWST eclipse observation. Not being confirmed by follow-up JWST observations, a verification of this atmospheric condition is still desired. High-resolution transmission spectroscopy enables us to infer the atmospheres of exoplanets from the ground, giving a complementary view to low-resolution investigations. We present 15 transit observations of 55 CNC e observed at the Large-Binocular-Telescope with the high-resolution spectrograph PEPSI. The inferred data yield probably the highest signal-to-noise transmission spectrum acquired to date for an exoplanet observation.
By investigating the presence of different atmospheric absorber species, our preliminary results hint at strong day-to-nightside winds as well as inefficient recycling of elements from the interior to the magma pool, resulting in the latter being probably mainly composed of Al_2O_3 and CaO. We compare our results with the former detection of volatile species on 55 CNC e and discuss scenarios that could explain both datasets at a glance."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

FROM DAYSIDE TO NIGHTSIDE: INSIGHTS FROM HIGH-RESOLUTION NEAR-INFRARED SPECTROSCOPY OF ULTRAHOT JUPITERS

Guo Chen &
Yuanheng Yang, Guo Chen, Fei Yan, Xianyu Tan, Hui Zhang

Purple Mountain Observatory, CAS; CAS Key Laboratory of Planetary Sciences, Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210023, China; School of Astronomy and Space Science, University of Science and Technology of China, Hefei 230026, China; Department of Astronomy, University of Science and Technology of China, Hefei 230026, China; Tsung-Dao Lee Institute & School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 201210, China; Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China.

The advent of high-resolution spectrographs on ground-based telescopes, together with the unprecedented capabilities of JWST, has opened new avenues for probing the multi-dimensional nature of exoplanet atmospheres. For ultrahot Jupiters, high-resolution spectroscopy near secondary eclipse has enabled detailed constraints on dayside thermal structures, chemical compositions, and atmospheric dynamics, providing key links between atmospheric properties and planet formation histories. In this talk, we present a recent dayside characterization of the hottest known exoplanet, KELT-9b, including the first molecular detection in its atmosphere. We also extend such studies from near-eclipse to near-transit phases using high-resolution near-infrared spectroscopy, aiming to reconstruct the three-dimensional thermal structure, chemical gradients, and dynamical patterns across the planetary atmosphere. Furthermore, we introduce a novel approach to disentangle nightside emission signals from high-resolution near-infrared transit spectra, offering a new pathway to directly probe the nightside atmospheres of ultrahot Jupiters.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

ATMOSPHERIC WIND MEASUREMENTS AS PROBES OF MAGNETIC FIELDS IN ULTRA-HOT JUPITERS

Julia V. Seidel &
Vivien Parmentier
Observatoire de la Côte d'Azur; Observatoire de la Côte d'Azur

"The magnetic field strength is arguably one of the most important characteristics of planets with far reaching implications from atmospheric retention to habitability. Nonetheless, current scaling laws are based on Solar System and stellar measurements only, despite decades long radio-observation campaigns of exoplanets, and predict values for exoplanets that differ by orders of magnitude. Ultra-hot Jupiters, with the strong ionisation of their atmospheres, provide a unique opportunity to empirically constrain these scaling laws given that the magnetic forces should directly affect atmospheric circulation.
In this talk, I present a comparative study of atmospheric wind measurements via the iron signature of known transiting ultra-hot Jupiters observed with ESPRESSO and MAROON-X. We reanalyse all available data for a homogeneous population survey and measure the wind speed of day-to-night winds in the upper atmosphere over a broad range of equilibrium temperatures.
We identify a clear and monotonic decrease in wind speed with increasing temperature. This behaviour is inconsistent with purely hydrodynamic circulation models but is naturally reproduced when magnetic drag is included. Interpreting the observed trend implies atmospheric magnetic field strengths of at most a few Gauss, comparable to maximally Jupiter's field strength.
These results establish observational constraints on magnetic fields in hot giant exoplanets and demonstrate that magnetic effects are a primary regulator of atmospheric circulation in strongly irradiated regimes. They provide a concrete benchmark for magnetic scaling laws and demonstrate the power of population studies in deducing secondary characteristics of the exoplanet population."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

CLOUDS, CHEMISTRY AND ISOTOPES IN Β PICTORIS B'S ATMOSPHERE

Dario Gonzalez Picos &
Ignas Snellen, Rico Landman, Sam de Regt, Natalie Grasser, Matthew Kenworthy
Leiden University

"High-resolution spectroscopy of directly imaged exoplanets has matured into a powerful tool for atmospheric characterisation, enabling molecular detections, measurements of planetary rotation, and constraints on atmospheric dynamics. Coupled with recent advances in retrieval techniques, high-resolution data now allow quantitative inferences on atmospheric composition, thermal structure, clouds, and increasingly subtle effects such as isotopic abundances and temporal variability.

We present a detailed atmospheric characterisation of the young super-Jupiter β Pictoris b based on twelve nights of VLT/CRIRES+ K-band high-resolution spectroscopy. This exceptional, high signal-to-noise, multi-epoch dataset enables a comprehensive investigation of the planet's chemical and physical properties. Using retrieval-based forward modelling of the high-resolution spectra, we robustly constrain the molecular composition and thermal structure of the atmosphere, finding a solar-like C/O ratio and a super-solar metallicity. We further report the detection of 13CO in the planet's atmosphere, enabling a measurement of a sub-solar 12C/13C ratio and demonstrating the unique capability of high-resolution spectroscopy to access isotopic ratios in exoplanet atmospheres. I will present results from both flexible and physically constrained retrieval frameworks, highlighting the complementary strengths of each approach.

Beyond composition, our retrievals reveal clear signatures of cloud opacity imprinted directly in the high-resolution spectra. In addition, the inferred temperature profile strongly favours atmospheric models with thick clouds, consistent with observations of other L dwarfs and with previous studies of β Pictoris b based on low-resolution spectroscopy. The combination of twelve nights of observations also enables a search for atmospheric variability on timescales of days to weeks, providing initial constraints on temporal changes in the atmosphere of a directly imaged exoplanet from high resolution spectroscopy.

β Pictoris b is a prime target for the ELT. Its brightness, angular separation, and rapid rotation make it ideally suited for Doppler imaging and temporally resolved atmospheric studies. High-resolution spectroscopy in the mid-infrared will expand the volatile and refractory inventory of detected species, and enable precise carbon and oxygen isotope ratios from the fundamental CO band. Our results highlight the transition of high-resolution exoplanet spectroscopy from detection-driven studies to precision atmospheric analysis, and provide a preview of the transformative science enabled by high-resolution spectroscopy on the next generation of telescopes."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, ...)

HIGH RESOLUTION EMISSION PHASE CURVE OF THE ULTRA HOT JUPITER WASP-33 B

Georgia Mraz &
Nicolas Cowan, Jennifer Glover, Vincent Yariv, Romain Allart, Joost Wardenier, Thea Hood, Florian Debras, Antoine Darveau-Bernier, Anne Boucher, Frédéric Genest

McGill Univervsity; McGill University, Université Grenoble-Alpes,Université de Montréal, University of Bern, Côte d'Azur Observatory, Institut de Recherche en Astrophysique et Planétologie

"Ultra-hot Jupiters (UHJs) represent the most extreme class of irradiated exoplanets, receiving up to 100 times more stellar flux than typical hot Jupiters and exhibiting dayside temperatures exceeding 2200 K. These planets are generally tidally locked, with short orbital periods that lead to extreme day–night temperature contrasts often greater than 1000 K. The intense irradiation on the dayside drives molecular dissociation and thermal inversions, while the cooler nightside allows for molecular recombination and non-inverted temperature profiles. Capturing a global picture of such planets traditionally requires space-based phase curves; however, recent advances suggest that near-infrared, ground-based high-resolution spectroscopy (HRS) may recover much of the same information.

As the only exoplanet with confirmed detections of nightside thermal emission with SPIRou on the Canada–France–Hawaii Telescope, WASP-33 b presents a uniquely well-characterized benchmark for HRS phase-curve studies. Building on prior dayside and nightside observations, we have obtained new quadrature-phase observations of WASP-33 b using SPIRou. These observations span orbital phases 0.13–0.37 and 0.68–0.85, totaling 16 hours. When combined with archival multi-night dayside and nightside SPIRou observations, these measurements nearly complete the planet's full orbital phase curve, marking the first time that all emission phases of an exoplanet have been pieced together using high-resolution spectroscopy with the same instrument, enabling a uniform and global view of the planetary atmosphere.

Preliminary analysis around phase 0.25 indicates well-behaved systematics and reveals tentative evidence for CO emission, consistent with the visibility of the hot dayside at quadrature. This result aligns with current global circulation model (GCM) predictions for UHJs and demonstrates the feasibility of recovering molecular signals from the ground, even outside of traditionally favorable orbital phases.

Our ongoing analysis aims to map the longitudinal distribution of CO in WASP-33 b's atmosphere and to investigate wind patterns through Doppler shifts in the planetary signal. To achieve this, we are developing and applying high-resolution analysis techniques optimized for orbital phases where the planet's radial acceleration is minimal. These are conditions under which traditional methods, such as Principal Component Analysis (PCA), can significantly reduce the planetary signal. These techniques are directly applicable to slower-moving, lower-mass planets, including systems such as TRAPPIST-1, as well as planned ELT observations of Proxima Centauri and other nearby non-transiting M-dwarf systems.

This work highlights the growing role of high-resolution spectroscopic phase curves in the ELT and JWST era. Together, the ELT and JWST will offer a pathway to comprehensive, multi-dimensional characterization of exoplanet atmospheres with unprecedented precision."

TAILS, TORII, AND TIDAL DECAY: OBSERVING THE MOST VIOLENT ATMOSPHERIC OUTFLOWS

Morgan Saidel &
Shreyas Vissapragada, Heather Knutson, Morgan MacLeod, Ethan Schreyer

California Institute of Technology; Carnegie Science Observatories; Division of Geological and Planetary Sciences, California Institute of Technology; Center for Astrophysics, Harvard & Smithsonian; Department of Astronomy & Astrophysics, University of California, Santa Cruz,

Planets orbiting early-type stars undergo a particularly violent form of atmospheric escape, with high Roche filling factors that lead to some of the fastest mass loss rates and most spatially extended outflows ever observed. For these planets, high spectral resolution observations of their time-varying metastable helium absorption signal can be used to characterize the outflow kinematics in the region immediately surrounding the planet. We present new Keck/NIRSPEC observations of metastable helium absorption from three gas giants orbiting F stars with high Roche filling factors and correspondingly strong predicted mass-loss rates. The outflows of these three planets were previously constrained with ultra-narrowband Palomar photometry centered on the metastable helium feature, which revealed that two of them (WASP-12 b and WASP-180 b) have extremely strong outflows, while a third (WASP-103 b) does not. Our new spectroscopic observations provide a first look at the kinematics of these three planetary outflows, revealing how Roche lobe overflow, day-night anisotropies, stellar winds, and magnetic fields sculpt their escaping atmospheres. For the tidally decaying WASP-12 b, this strong outflow is particularly consequential: recent theoretical work has shown that if the escaping atmosphere forms a torus, the resulting back-reaction could counteract tidal orbital decay and push the planet outward. We compare our outflow observations to predictions from 3D outflow models, resulting in new insights into the role of Roche lobe overflow in driving the strong observed mass loss rates and corresponding orbital evolution of these planets.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

LINKING MIGRATION TO ATMOSPHERIC ESCAPE: FIRST RESULTS FROM THE ATREIDES SURVEY OF EXO-NEPTUNES

Gaia Lacedelli &
Vincent Bourrier, Ares Osborn, Marina Lafarga Magro, Edward Bryant, Isobel Lockley, Erik Fridén, and the ATREIDES collaboration
Instituto de Astrofísica de Canarias (IAC)

"More than 60% of known exoplanets orbit their host stars in less than 30 days. This close-in population ranges from small rocky planets to gas giants, and its current configuration is shaped by a complex interplay between atmospheric and dynamical processes. Exo-Neptunes are particularly sensitive tracers of these mechanisms. Their distribution shows a dearth of hot Neptunes at short periods (the so-called ""Neptunian Desert""), and a mildly populated region at longer periods (the ""Neptune Savanna""), separated by an over-density known as the ""Neptunian Ridge"". The role of atmospheric escape in sculpting these features, and whether and when atmospheric loss occurred during the evolution history of this population is still under debate. To understand their atmospheric survival and overall evolution, it is essential to determine whether these planets migrated in early phases via disk-driven migration or later on through high-eccentricity migration.
In this context, the ATREIDES collaboration is exploring the exo-Neptunian landscape through a systematic census of 60 close-in Neptunes using high-resolution transmission spectroscopy with ESPRESSO to measure their 3D orbital architecture, a key tracer of migration, and their atmospheric mass loss.
I will present the initial results from several benchmark ATREIDES targets that sample this diverse landscape, focusing on the measurement of their spin-orbit angle and orbital architecture, and on how characterizing the evolutionary pathway at a population level can start revealing the true origins of close-in Neptunes."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

PROBING THE UNIQUE GIANT EXORING CANDIDATE ASASSN-21JS

Niamh Mallaghan
Queen's University Belfast

"ASASSN-21js is a remarkable long-duration dimming event discovered when the deep eclipse began in 2021 and is predicted to continue until mid-2027. The depth and duration are inconsistent with common forms of stellar variability or transiting object, making ASASSN-21js one of the most promising giant exoring candidates identified to date. Best-fit models suggest a circumplanetary ring system extending to ~2.1au, with only the outermost rings transiting the host star.
I will present the results of a multi-epoch spectroscopic campaign using GHOST. These data probe physical and chemical properties of the transiting material and its host system, including the ring's geometry, composition and host's stellar parameters. This represents one of the first dedicated efforts to study a candidate giant exoring in real time. Results will not only test theoretical models of ring dynamics and disk evolution but also establish a methodological framework for identifying and characterising similar systems in future surveys."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

A JWST SURVEY OF THE SUB-NEPTUNE REGIME: NEW INSIGHTS INTO UNCHARTED TERRITORY

Nikku Madhusudhan &
Subhajit Sarkar, Mans Holmberg, Frances Rigby, Lorenzo Pica-Ciamarra, Julianne Moses, Savvas Constantinou, Martin Binet, Greg Cooke, Edouard Barrier, Anjali Piette, Megan Mealing
University of Cambridge

Sub-Neptune exoplanets, with sizes and masses between those of Earth and Neptune, dominate the exoplanet population. Sub-Neptunes are arguably the most diverse family of the exoplanet population, potentially including rock-dominated gas dwarfs, water worlds, and mini-Neptunes, with a wide range of atmospheric, surface and interior conditions. With no analogue in the solar system, these planets open fundamental questions in planetary processes and origins. The advent of JWST is revolutionising this frontier with unprecedented detections of atmospheric signatures of transiting sub-Neptunes. In particular, sub-Neptunes orbiting nearby M dwarfs present a promising avenue for their atmospheric characterisation. We will present new results from a large atmospheric survey of temperate sub-Neptunes using JWST transmission spectroscopy obtained with over 100 hours of JWST time and three different JWST instruments spanning the near-infrared and mid-infrared. Our targets span a diverse range of masses and radii in the sub-Neptune regime, over an equilibrium temperature range of 250-400 K where important transitions in internal structure and atmospheric composition are expected. All the targets in the sample reveal strong spectral features which lead to unprecedented insights into the compositional diversity in the sub-Neptune regime. We will report constraints on their atmospheric chemical compositions, temperature structures, clouds/hazes, and their implications for the atmospheric processes and interior/surface conditions of the planets. We identify key trends and transitions in the atmospheric properties which provide important population-level constraints on the bulk compositions, disequilibrium processes, presence of surfaces and formation pathways of sub-Neptunes. We will discuss these results in the context of emerging theoretical frameworks to characterise the nature and origins of the sub-Neptune population.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

COMPETING CHEMICAL SIGNATURES IN THE ATMOSPHERE OF TOI-270 D

Lukas Felix &
Daniel Kitzmann (1, 2), Christoph Mordasini (1, 2), Brice-Olivier Demory (2, 1, 3)

Department of Space Research and Technology, Technical University of Denmark, Elektrovej 328, 2800 Kgs. Lyngby, Denmark; 1) Division of Space Research and Planetary Sciences, Physics Institute, University of Bern, 3012 Bern, Switzerland, 2) Center for Space and Habitability, University of Bern, Gesellschaftsstrasse 6, 3012 Bern, Switzerland, 3) ARTORG Center for Biomedical Engineering Research, University of Bern, Murtenstrasse 50, 3008 Bern, Switzerland

"TOI-270 d, a sub-Neptune (Rp ≈ 2.2 R⊕, Teq ≈ 340 K) orbiting a nearby M3V star, offers an exceptional opportunity for atmospheric characterization of a temperate sub-Neptune with the James Webb Space Telescope (JWST). Recent analyses of transit data from NIRSpec and NIRISS have yielded conflicting interpretations of the planet's atmosphere: a high-metallicity, miscible envelope (Benneke et al. 2024) versus a lower metallicity "hycean" world (Holmberg &
Madhusudhan 2024, Constantinou et al. 2025). To resolve this discrepancy, we conducted an independent data reduction and retrieval analysis of the present NIRSpec/BOTS G395H and NIRISS/SOSS GR700XD data (spanning 0.8–5.2 μm) at native instrument resolution.
Our fiducial retrieval results reveal a high-metallicity atmosphere (M/H ≈ 160× solar) with an elevated mean molecular weight (μ ≈ 5.6 amu), confidently detecting CH4 and CO2. But we also find that the Bayes Factor in favor of the inclusion of CS2 and NH3 are highly dependent on the deployed spectral resolution, varying between 3-78. We therefore demonstrate that coarse spectral binning introduces biases, particularly for molecules that do not dominate the shape of the spectrum.
Equipped with a solid baseline atmosphere model, we test for the potential presence of various other molecules. We identify multiple majorly favored configurations (Bayes Factor 600-16000). Most plausibly, we find a rich sulfur chemistry containing both H2CS and CS at well restricted abundances, potentially providing chemical pathways that could explain the large abundance >0.1% of CS2 found across all retrievals. Alternatively, the inclusion of CH3Cl or CH3F, retrieved at abundances of > 100 ppm, leads to similar improvements in the Bayesian evidence, as does any combination of these molecules and the aforementioned sulfur model. The data alone does not allow us to identify a preferred model, due to the fact that the opacities of CH3Cl, CH3F and H2CS are almost identical in our probed spectral range.
Our results highlight critical challenges in characterizing temperate sub-Neptunes. The degeneracy between biosignature gases (e.g., CH3Cl and CH3F) and abiotic sulfur compounds, like H2CS, underscores the need for the detailed exploration of sulfur-chemistry in the temperature regime of planets like TOI-270 d. Furthermore, we demonstrate that large Bayes Factors can be achieved at higher spectral resolutions, even for species lacking isolated absorption features, emphasizing the importance of carefully selecting spectral resolution and accounting for its impact when analyzing transmission spectroscopy data."

ROOM 2

02/07 17:00–17:15

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

ATMOSPHERIC CHARACTERIZATION OF K2-18 B FROM COMBINED JWST TRANSMISSION SPECTROSCOPY

Alexandre Souza &
Diogo Souto
Departamento de Física , Universidade Federal de Sergipe, Av. Marcelo Deda Chagas, s/n , 49107-230, são Cristóvão, Se, Brazil

“We present a detailed atmospheric study of the exoplanet K2-18 b based on transmission spectroscopy observations obtained with the James Webb Space Telescope (JWST). The data were processed using the texttt{Eureka!} pipeline and modeled with the atmospheric retrieval code texttt{petitRADTRANS}. We combine transmission spectra from the MIRI, NIRSpec, and NIRISS instruments, covering a broad wavelength range from 0.6 to 12 μm. This unified spectral dataset enables a comprehensive assessment of the planet’s atmospheric composition and allows for direct comparison with recent results in the literature.

The combined analysis reveals atmospheric abundances consistent with the presence of CH$_4$, H$_2$O, CO$_2$, and CO, demonstrating the ability of the retrieval framework to recover molecular signatures even in the presence of significant uncertainties in the atmospheric temperature structure. We explore multiple scenarios proposed for the nature of K2-18 b and evaluate their statistical robustness. Alternative interpretations, such as a mini-Neptune–like atmosphere, do not show strong statistical convergence, indicating that the current data remain insufficient to decisively discriminate between competing physical scenarios.

We further investigate the presence of complex molecules associated with potential biosignatures, including dimethyl sulfide (DMS) and dimethyl disulfide (DMDS), and find no statistically robust evidence supporting their detection. This result highlights both the limitations of current observations and the importance of future JWST measurements, as well as continued improvements in molecular opacity databases.

Overall, this study contributes to the ongoing debate regarding the atmospheric properties and potential habitability of K2-18 b. It also demonstrates the transformative power of JWST, in combination with advanced atmospheric modeling tools, for probing the composition and physical nature of temperate exoplanets orbiting M-dwarf stars.”

HOT HOSTS AND COOL NEPTUNES: JWST OBSERVATIONS OF HD106315C AROUND AN F-TYPE STAR

Achrene Dyrek &
Achrene Dyrek1, Rens Waters2, Billy Edwards3, Shang-Min Tsai4, Jeroen Bouwman5, Mans Holmberg1, John Pye6, Manuel Guedel7, Jesse Polman8, Michiel Min3, Pierre-Olivier Lagage9, Nicolas Crouzet10, Sarah Kendrew1, Yamila Miguel10, Thomas Henning5, Martin Topinka11, Olaf Renes2, Niloofar Khorshid12, David Barrado13, Maria Morales-Calderon14, Leen Decin15, Wiebe De Gruijter16, Peter Daamen2, Rick Van Gompel2

1: STScI, Baltimore, MD, 2: Radboud University, Nijmegen, 3: SRON, Leiden, 4: Academia Sinica Insitute of Astronomy and Astrophysics, Taipei, 5: MPIA, Heidelberg, 6: University of Leicester, Leicester, 7: University of Vienna, Vienna, 8: University of Bern, Bern, 9: CEA Saclay, Gif-sur-Yvette, 10: Leiden University, Leiden, 11: Dublin Institute for Advanced Studies, Dublin, 12: University of Amsterdam, Amsterdam, 13: The Spanish National Research Council, Madrid, 14: CSIC, Madrid, 15: KU Leuven, Leuven, 16: Anton Pannekoek Institute for Astronomy, Amsterdam

"Warm Neptunes occupy a critical regime between rocky super-Earths and gas giants, and their atmospheres encode both formation pathways and irradiation-driven evolution. Yet nearly all well-characterized examples orbit cool M-type stars, leaving open a fundamental question: do atmospheric trends inferred around M dwarfs propagate to planets around hotter, Sun-like stars? We present new JWST/MIRI (5-12 μm) transmission spectroscopy of HD106315c, a warm Neptune (Rp ~ 4.3 Earth radii, P = 20 days, Teq ~ 800 K) orbiting a bright F-type star, one of the hottest hosts known for a transiting Neptunian planet. This system is a natural outlier and a benchmark for extending atmospheric studies beyond the M-dwarf regime.
HD106315 hosts two transiting planets that straddle the radius gap, with an inner Super-Earth and an outer Neptune, making it a unique laboratory for studying atmospheric loss, volatile retention, and composition across planetary regimes within a single stellar environment. The irradiation received by HD106315c places it in a prime regime for photochemistry, where sulfur species such as SO2 are predicted to emerge. Contrary to expectations, our JWST/MIRI observations reveal no SO2, while robustly detecting H2O and NH3, with tentative evidence for OCS. The non-detection of SO2 provides a stringent upper limit that extends the ""SO2 shoreline"" [Crossfield, 2025] to a markedly different stellar type, opening this framework to a broader and previously unexplored region of parameter space.
The simultaneous detection of nitrogen-bearing species and the absence of sulfur in oxidized form give us hints on the atmospheric N/S ratio, directly testing planet formation models in which sulfur behaves as a refractory element scaling with metallicity, while nitrogen traces volatile delivery. Our results suggest super-solar O/H and N/H ratios with a near-solar N/O, offering new insight into how formation and irradiation jointly sculpt warm Neptune atmospheres around hot stars. HD106315c thus emerges as a keystone object for connecting M-dwarf Neptunes, planets around Solar-type stars, and ultimately the ice giants of our own Solar System and sets the stage for future broad-wavelength JWST studies to complete this emerging picture."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

JWST TRANSMISSION SPECTRUM OF A BENCHMARK TEMPERATE SUB-NEPTUNE

Lorenzo Pica-Ciamarra &
M. Holmberg; N. Madhusudhan; J. I. Moses; F. E. Rigby; S. Sarkar
IoA – University of Cambridge; Space Telescope Science Institute; University of Cambridge; Space Science Institute; Imperial College London; Cardiff University

"Characterising the atmospheres of temperate sub-Neptunes and understanding the processes that operate in them are key frontiers of exoplanet science. We present the JWST transmission spectrum of a temperate sub-Neptune with a hydrogen-dominated atmosphere and an equilibrium temperature T_eq < 400 K. The planet, at ~2 Earth radii, is part of the large-radius population of the sub-Neptune radius valley. This planet is part of a unique two-planet pair with a second, warmer companion lying in the small-radius peak of the radius valley, resulting in a valuable configuration for comparative studies. The host star, a nearby bright M dwarf, makes the system an excellent target for atmospheric spectroscopy.
We report a JWST transmission spectrum of this temperate sub-Neptune showing clear signs of molecular absorption. We present the inferred atmospheric composition, highlighting its implications for the internal structure of the planet and the origins of the radius valley. We report constraints on the prominent CNO species, including the inference of abundant methane, relative to other species such as carbon dioxide and carbon monoxide. The strong constraints we find on ammonia also provide an important diagnostic for the planetary interior. Furthermore, strong evidence is present for clouds and hazes, as well as for additional absorption features, potentially hinting at complex chemistry.
By combining atmospheric constraints on this sub-Neptune with the shared formation history of this radius-valley–spanning system, we make predictions for atmospheric properties of the smaller companion planet. These can be tested with current and future observations, establishing this system as a benchmark for testing scenarios for the origin of the radius valley. We further place this temperate sub-Neptune in context by comparing its atmospheric properties with those of other temperate exoplanets observed with JWST, including new datasets that yield strong ($\geq 10\sigma$) molecular detections. These results demonstrate the power of JWST in aiding our understanding of processes in temperate atmospheres and their link to formation history and present internal structures."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

BOWIE-ALIGN: A POPULATION-LEVEL COMPARISON OF ALIGNED AND MISALIGNED HOT JUPITER ATMOSPHERES

James Kirk &
Eva-Maria Ahrer and the BOWIE-ALIGN team
Imperial College London; Several institutions

Understanding how giant planets form and migrate remains a central challenge in exoplanet science. Atmospheric composition offers a window into formation history, but this connection can be obscured by myriad chemical and dynamical processes. The BOWIE-ALIGN programme introduces orbital alignment as a complementary diagnostic, enabling the first population-level comparison of aligned and misaligned hot Jupiters' JWST transmission spectra. Aligned planets are expected to have migrated through the disc, while misaligned planets likely followed disc-free migration pathways, which are predicted to imprint distinct atmospheric compositions through different accretion histories. We target hot Jupiters orbiting F-type stars above the Kraft break, where tidal realignment is inefficient, so obliquities reliably trace migration history. Here, we present the full BOWIE-ALIGN sample: four misaligned and three aligned hot Jupiters, including five newly extracted and two reprocessed archival spectra. Using a uniform reduction and retrieval framework, we compare atmospheric abundances and spectral colours across the ensemble. Both diagnostics broadly indicate metal-enriched, low-C/O atmospheres. In colour–colour space, misaligned planets exhibit stronger CO_2 and SO_2 absorption relative to H_2O, indicative of a compositional difference between the two populations. Retrievals, providing a more conservative and model-dependent perspective, do not yet reveal a statistically robust difference between the populations, highlighting the complementary insights of both approaches. Together, these results demonstrate the promise of combining obliquity measurements with atmospheric characterisation to probe giant planet formation and migration pathways.

ROOM 2
02/07 18:00–18:15

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE 3D RUNAWAY GREENHOUSE EFFECT ON TEMPERATE SUB-NEPTUNES

Edouard Barrier &
Nikku Madhusudhan
University of Cambridge; University of Cambridge

Sub-Neptunes represent the current frontier of exoplanet atmospheric characterisation, with recent JWST observations of a string of temperate sub-Neptunes such as K2-18b, TOI-270d, TOI-732c, and LP 791-18 d. Accurate modelling of atmospheric processes is essential to interpreting high-precision spectroscopic data given the wide range of possible conditions in the sub-Neptune regime, including on some potentially habitable planets. 3D General Circulation Models (GCMs) can provide the sophistication to model fully self-consistent atmospheres, but care needs to be taken with their modelling of complex physical effects. In particular, the runaway greenhouse effect is a process which is still poorly understood on temperate sub-Neptunes, as it depends on the interplay between moist convection, radiation, and atmospheric composition. It is, however, extremely important, as it controls the possibility of a sub-Neptune being a 'Hycean' with a liquid water ocean. To explore this effect in detail, we conduct General Circulation Model (GCM) simulations of water-world sub-Neptunes, using a modified version of the ExoCAM GCM. Investigating a range of instellations, atmospheric sizes and compositions, we study the resulting climates and dynamical structures, and we place multi-dimensional constraints on the runaway greenhouse limits in sub-Neptune atmospheres. We find that both hazes and abundant CH$_4$ can significantly affect the atmospheric structure and delay the runaway greenhouse effect. By comparing the necessary haze abundances to transmission spectroscopy observations, we impose limits on the possibility of liquid water on current temperate sub-Neptune targets, helping constrain their composition.

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE FIRST SPECTRUM OF A MATURE COLD JUPITER IN OUR BACKYARD AND THE FIRST EXOPLANETARY DETECTIONS OF CH3D AND 15NH3

Jerry Xuan &
Jean-Baptiste Ruffio, Alexis Bidot, Yapeng Zhang, Aniket Sanghi, James Mang, Caroline Morley, Dimitri Mawet, Heather Knutson, Elisabeth Matthews, Marshall Perrin, Jason Wang, Mathilde Malin, William Thompson, Alex Madurowicz, Rebecca Oppenheimer, Christian Marois, Bjorn Benneke, Carrie He

University of California, Los Angeles

∊ Indi Ab is the first mature (~4 Gyr) cold Jupiter (Teff~275 K, ~7 MJup) imaged around another star. The landmark detection of this planet with JWST/MIRI has opened a new chapter in exoplanet studies. Located only 3.6 parsecs away, the planet is ideally suited for detailed spectroscopic characterization. We present JWST NIRSpec and MIRI high-contrast spectroscopy of ∊ Indi Ab from 3-16 um at a resolving power of ~3000. Despite the low temperature of the planet, these observations represent some of the highest quality spectra ever acquired for an exoplanet. Besides the main isotopologues of CH4, H2O, CO, H2S, NH3, and CO2, we detect a record-breaking number of seven different minor isotopologues, including CH3D and 15NH3. We discuss constraints on the D/H, 15N/14N, 16O/18O, 17O/18O, 12C/13C ratios from atmospheric retrievals, and their implications for the formation and accretion history of the planet. We also present new insights into the planet's atmospheric chemistry, metallicity, and clouds from the atmospheric retrievals, as well as from comparing the planet's spectrum to that of the brown dwarf WISE 0855, a close cousin in terms of effective temperature.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

GAIA ASTROMETRIC SUBSTELLAR COMPANIONS: DR3 RV FOLLOW-UP AND DR4/DR5 FORECASTS FOR MUTUAL INCLINATIONS

Kamil Kalinowski &
Simon Albrecht, Marcus Marcussen

Department of Physics and Astronomy, Aarhus University, Ny Munkegade 120, DK-8000 Aarhus C, Denmark; Department of Physics and Astronomy, Aarhus University

"Gaia astrometry is starting to reveal the wide-orbit companion population—brown dwarfs and giant planets—on multi-au orbits. As with any exoplanet detection technique, astrometry has a false-positive channel. The reflex motion of a single star induced by a substellar companion can be mimicked by an unresolved double-lined spectroscopic binary via its photocenter motion, making follow-up essential. We address this with a spectroscopic program covering both hemispheres using, among other instruments, NIRPS on the ESO 3.6 m and FIES on the Nordic Optical Telescope, obtaining multi-epoch radial velocities and line-profile diagnostics for Gaia DR3 astrometric companion candidates.

In a sample of more than 50 DR3 candidates, roughly two-thirds are false positives. For the vetted remainder, we combine RV constraints with DR3 astrometric solutions to refine companion-orbit posteriors. We summarize our vetting workflow relevant for the much larger DR4 (scheduled for December 2026) and DR5 candidate samples, enabling comprehensive demographics of wide-separation giants and brown dwarfs.

We will also present our forecast of what we can learn about mutual inclinations in already-known multi-giant RV systems by adding Gaia epoch astrometry from DR4/DR5. We quantify how the results depend on orbital geometry and the Gaia scanning law, rank the best targets, and show that Gaia+RV will measure mutual inclinations to a few-degree precision for a handful of the most favorable systems—enabling tests of dynamically cold versus hot giant-planet architectures."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

IN THE COMPANY OF TWO : NIRPS HUNTS PLANETS IN BINARY SYSTEMS

Lina Messamah &
F. Bouchy, Y. Frensch, NIRPS Consortium
Observatory of Geneva

"Understanding planet formation in multiple-star systems requires access to close visual binary configurations that have long remained observationally challenging. Flux contamination and limited angular resolution have historically hindered precise radial-velocity follow-up of transiting planets in binary systems, particularly around low-mass stars.
I will present a dedicated NIRPS (Near Infra-Red Planet Searcher) Guaranteed Time sub-program designed to overcome these limitations by targeting transiting exoplanets in binary systems at short angular separations. Operational since 2023 on the ESO 3.6 m telescope at La Silla, NIRPS combines near-infrared wavelength coverage with adaptive optics and a 0.4 arcsec on-sky fiber, enabling precise Doppler measurements while strongly mitigating contamination from close stellar companions. This capability opens a new observational window on planets in multiple-star environments that were previously inaccessible to radial-velocity surveys. The program focuses on transiting exoplanets orbiting low-mass stars (K5–M9) in binary systems, aiming to measure planetary masses and bulk densities in a largely unexplored regime. In this talk, I will present the first results and initial detections from this program, including the characterization of a short-period giant planet (P =1.77 days, R =10.96 R_earth) orbiting one component of a near-equal-mass M-dwarf binary. These early results illustrate the unique potential of NIRPS to probe planet formation and evolution in close visual stellar binaries."

A JWST NIRSPEC PHASE CURVE OF THE ULTRA-HOT SUPER-JUPITER TOI-2109B

Nicole Wallack &
Julie Inglis, John Allen, Yayaati Chachan, Fei Dai, Guangwei Fu, Michael Greklek-McKeon, Tiffany Kataria, Heather Knutson, Thaddeus Komacek, Daniel Thorngren, Shreyas Vissapragada, Ian Wong, Jerry Xuan

Carnegie Earth and Planets Laboratory; UC San Diego, University of Oxford, UC Santa Cruz, University of Hawai'i, Johns Hopkins University, Carnegie Earth and Planets Laboratory, Jet Propulsion Laboratory, Caltech, University of Oxford, Johns Hopkins University, Carnegie Observatories, Space Telescope Science Institute, UCLA

The ultra-short-period planet TOI-2109b occupies a unique region of planetary parameter space, providing a valuable benchmark for understanding the formation and evolution of ultra-hot Jupiters. At ~5 Jupiter masses and ~3100 K, this super-Jupiter orbits its F star host in just ~16 hours, offering new insights into planet formation and atmospheric dynamics. Its mass lies in a regime where both core accretion and disk instability are plausible formation pathways, potentially distinguishable through atmospheric and interior composition. With an equilibrium temperature intermediate to KELT-9b (~4000 K) and other ultra-hot Jupiters (<2800 K), TOI-2109b is a critical benchmark for testing day-night circulation models in a previously unexplored temperature regime for infrared phase curves. I will present results from our Cycle 4 JWST NIRSpec/G395H phase curve observation of TOI-2109b, including phase curve modeling, constraints on orbital decay, and atmospheric retrievals of the dayside and nightside emission spectra. We find evidence of a unique atmospheric composition as compared to other giant planets. We also measure a larger day–night temperature contrast than observed for KELT-9b, suggesting that heat transport remains inefficient at temperatures of ~3100 K, or indicating that nightside clouds are present on TOI-2109b. I will contextualize these results with other ultra-hot Jupiter observations and highlight the implications for the formation histories of these planets.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE NEPTUNIAN RIDGE: A DYNAMICAL FINGERPRINT OF CLOSE-IN PLANET EVOLUTION

Amadeo Castro-González
Geneva Observatory

"The close-in Neptunian population shows one of the most striking structures in exoplanet demographics. Recent occurrence-rate analyses reveal that the transition from the ultra-short-period Neptunian desert to longer orbital periods is not smooth, but instead features a narrow overdensity of planets at orbital periods of about 3.2–5.7 days, known as the Neptunian ridge. This feature suggests the presence of a preferred accumulation region for close-in Neptunes.

In this talk, I will argue that focusing on the Neptunian ridge provides a fundamentally new perspective on the origin of close-in Neptunian planets. Beyond occurrence rates, ridge planets exhibit distinctive trends in bulk density, orbital eccentricity, spin–orbit alignment, and host-star properties, setting them apart from the longer-period Neptunian savanna. These observational signatures point toward a dynamical origin and are naturally consistent with scenarios in which Neptunian planets form at large orbital distances and are delivered inward through high-eccentricity migration.

By treating the Neptunian desert and ridge as a coupled architectural feature rather than independent phenomena, we gain a unified framework to test migration pathways and survival processes shaping close-in planets. I will conclude by discussing how ongoing population-level surveys can use densities, obliquities, atmospheric escape, and outer-companion demographics to critically test this emerging picture."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

FORMATION OF COMPACT SYSTEMS DURING DISK INFALL

Robin Canup &
Raluca Rufu
Southwest Research Institute; Southwest Research Institute

"A longstanding assumption is that planetary growth commences after the infall of gas and solids to a circumstellar disk ends, with disk infall and planet accretion traditionally modeled as two separate phases. While conceptually and computationally convenient, this division may not always be physically valid: indeed, there is substantial observational evidence that accretion commences early and even during infall in some systems.
We are developing a first generation of simulations to assess the effects of planet accretion during late disk infall on resulting system properties. In Rufu & Canup (2025), we focus on compact systems, whose short orbital timescales imply that once > km-sized planetesimals form, full planet accretion proceeds rapidly on timescales shorter than or comparable to infall timescales. We simulated planet growth within a disk supplied by an infall with small centrifugal radius, r_c ~ 0.1 to 0.5 au. In disk regions undergoing infall (i.e., for r < r_c,), planet masses are set by a balance between accretion of infalling solids and Type I migration. This produces a similar planet size within each system, consistent with the observed "peas-in-a-pod'' structure, which can also be explained by prior, post-infall formation models.
More notably, Rufu & Canup (2025) find that accretion during infall explains two traits of compact systems that are not easily explained by standard, post-infall models. First, compact systems display a remarkably consistent ratio between the total planetary mass and the stellar mass, with this ratio being few times 10^{-5} to 10^{-4} across systems whose stellar masses vary by an order-of-magnitude. Why such a preferred mass ratio would exist for varied stellar masses and disk evolutions has been a mystery. We show that accretion during infall regulates a compact system to have this common mass ratio for a wide range of disk and infall conditions. Second, the mass of compact system planets shows an unusually weak dependence on stellar metallicity, in contrast to, e.g., gas giants. For a standard post-infall model, planet masses would generally be proportional to metallicity, in contrast to the observational trend. We find that accretion during infall yields planet and planet system masses that have only a weak dependence on metallicity, providing an explanation to this long-standing problem.
We will discuss observational implications of planet accretion during infall and key areas for further advancement. The latter include a better understanding of where and when early planetesimals may form.
Rufu, R. and R. M. Canup (2025) "Origin of compact exoplanetary systems during disk infall" Nature Communications, 16, 4853."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

ELEMENTAL ABUNDANCES OF THE HR 8799 PLANETS REVEAL HALLMARKS OF PEBBLE FORMATION

Jean-Baptiste Ruffio &
Jerry W. Xuan, Yayaati Chachan, Kazumasa Ohno, Aurora Kesseli, Ruth Murray-Clay, Eve J. Lee, Julianne I. Moses, William O. Balmer, Aneesh Baburaj, Geoffrey A. Blake, Doug Johnstone, Yapeng Zhang, Heather A. Knutson, Dimitri Mawet, Charles Beichman, Klaus Hodapp, Marshall D. Perrin, Quinn Konopacky, Michael Meyer, Geoffrey Bryden, Thomas P. Greene, Jarron Leisenring, Marie Ygouf, Björn Benneke, Julie Inglis, Nicole L. Wallack, Sarah Steiger, Corey Spohn, Bruce Macintosh, Laurent Pueyo, Bertrand Mennesson, Beck Dacus, Nicole Wolff, Renyu Hu, Kielan Hoch, Dmitry Savransky, Michael W. McElwain, Shelley A. Wright, Ji Wang, Pin Chen, Tyler D. Robinson
UC San Diego

"The detection of refractory and volatile species in exoplanet atmospheres can independently trace the accretion of solids (pebbles or planetesimals) from the accretion of metal-enriched gas in the protoplanetary disk. We observed the four HR 8799 planets (5-9 MJup) with JWST/NIRSpec IFU (2.9-5.3 um; R~2,700) and unambiguously detected CO, CH4, H2O, H2S, CO2, and even NH3 in the atmosphere of planet b. The retrieved abundances for the refractory sulfur, volatile nitrogen, carbon and oxygen across the system show tantalizing trends that are consistent with pebble drift and evaporation at the CO and N2 snowlines given the planets' current semi-major axes. These findings suggest that massive and distant directly imaged-planets likely formed similarly to the solar system planets. I will highlight the progress and lessons learned of our on-going survey to measure refractory (S, K, Na, Fe) and volatile (C, O, N) abundances of directly imaged planets (5-20 MJup and >10 au) with JWST/NIRSpec.
By resolving the distinct spectral features of chemical species in exoplanet atmospheres, moderate to high-resolution spectroscopy (R>1000) has proven transformative to detect trace molecules and precisely measure their abundances. A primary goal of the Habitable Worlds Observatory (HWO) is to detect and measure the abundance of biosignature molecules, such as water (H2O) and oxygen (O2), in the atmosphere of Earth analogs. I will also discuss the results of our simulations of Earth analogs around 164 stars that suggest that a moderate-resolution spectrograph (R>1,000) could be optimal, and even necessary, to detect biosignatures with HWO."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

THE CHEMICAL LANDSCAPE OF GIANT PLANET FORMATION

Alice Booth
Center for Astrophysics, Harvard & Smithsonian

New planetary systems are made from dust, gas, and ice in the rotating disks around young stars. We can therefore only unravel exoplanet composition demographics through our knowledge of protoplanetary disk chemistry. For this, high-sensitivity observations of these disks with the Atacama Large Millimeter Array (ALMA) are essential. ALMA allows us to observe the emission lines of various molecules in disks down to 10 au scales. We can therefore use ALMA to trace the composition of the gas available to be incorporated into forming planets and other smaller bodies. In this talk, I will present a census of molecular line observations toward disks around ~1.5–2.5 solar-mass stars. As gas giant planets are more likely to form in disks around these slightly more massive stars than the Sun, these observations probe the chemical environment of giant-planet formation. The data show that the observed chemical diversity across these disks leads to varying C/O regimes at the orbital radii of candidate protoplanets identified within them. Furthermore, when comparing these inferred disk C/O ratios with those measured for directly imaged exoplanets, we find a notable overlap and show that low C/O gas is common on tens of au scales in these disks. To conclude, I will discuss what can be learned from complementary observations of disks with JWST, what we can expect from the next generation of ALMA and prospects for the direct detection of planets via chemical asymmetries in disks driven by planetary heating and/or shocks.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

POSEIDON: THE DYNAMICAL ORIGINS OF HOT AND WARM NEPTUNES

Juan Espinoza-Retamal
Princeton University

Stellar obliquity measurements provide a powerful probe of the formation and dynamical evolution of planetary systems. However, current measurements are strongly biased toward giant planets, making it unclear whether the observed features of the obliquity distribution are representative of the broader exoplanet population. In particular, it remains unknown whether close-orbiting small planets underwent orbital migration via mechanisms analogous to those that have been studied for hot Jupiters. Here, I will present early results from a program to measure obliquities of stars with transiting Neptune-size and Neptune-mass planets. Contrary to previous claims in the literature, with an updated sample, we find no strong clustering near 90 deg. The evidence for a preponderance of polar orbits among these planets has weakened. Instead, the distribution is unimodal and peaked at 0 deg, with a broad tail of misaligned systems that resembles the distribution observed for hot Jupiter hosts. This similarity suggests that hot Jupiters and Neptunes do migrate through similar dynamical processes. We also find that when the transiting Neptune is part of a compact multi-planet system, the star is very likely to have a low obliquity, with a few notable exceptions.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

OBSERVING AND MODELING THE ORBIT OF A 542-DAY TRANSITING GIANT WITH LARGE TRANSIT TIMING VARIATIONS

Pietro Leonardi &
S. Grouffal, A. Santerne, L. Borsato

Università degli studi di Padova; 1) Aix Marseille Univ, CNRS, CNES, Institut Origines, LAM, Marseille, France – 2) Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France – 3) INAF, Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, 35122 Padova, Italy

"Characterizing long-period transiting exoplanets is inherently challenging due to the rarity and long duration of transit events, yet these systems provide unique insights into planetary formation and migration, exomoons detection and primordial atmospheres by probing a sparsely populated region of the exoplanet parameter space. The complexity increases further for long-period planets near mean-motion resonances, where transit timing variations (TTVs) can reach amplitudes of several hours to days.
We present a coordinated space- and ground-based observing campaign, using photometry from NEOSSat, multiple LCOGT sites, MuSCAT3 and Tierras, to capture the 19-hour transit of the long-period giant exoplanet HIP 41378 f (P = 542 days) on 31 October 2025. Our transit analysis constrains the time of inferior conjunction to TC,7 = 2460980.893 ± 0.028 BJDTDB, occurring 1.7 hrs later than predicted, making HIP 41378 f the longest-period transiting exoplanet known to exhibit measurable TTVs. By combining this new precise measurement to the transit timings of the two outer planets in the system (HIP 41378 d and HIP 41378 e), we perform a dynamical modeling of the system, refine the ephemeris of HIP 41378 f, and predict future transit events for all three outer transiting planets."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

DISTINCT ECCENTRICITY – STELLAR OBLIQUITY TRENDS IN THREE GAS-GIANT MASS REGIMES

Xian-Yu Wang &
Wang, Songhu ; Batygin, Konstantin
Indiana University; Indiana University; California Institute of Technology

Understanding the joint distribution of orbital eccentricity and stellar obliquity provides a powerful diagnostic of planetary migration histories. However, heterogeneous analyses and inconsistent treatments of uncertainties have long obscured potential empirical trends. We present a uniform reanalysis of 220 exoplanet systems with Rossiter–McLaughlin measurements and radial velocities. Using a modified version of EXOFASTv2 that jointly fits spectral energy distributions, transit light curves, radial velocities, and RM signals, we derive robust and internally consistent posteriors for eccentricity and obliquity across the entire sample. Our results reveal, for the first time, three distinct dynamical populations in the eccentricity–obliquity plane: (1) sub-Saturns can exhibit both large eccentricities and strong spin–orbit misalignments; (2) Jupiters are misaligned only when nearly circular, predominantly around hot stars; and (3) massive Jupiters and brown dwarfs remain aligned regardless of eccentricity. The observed structure provides new constraints on tidal realignment efficiency and migration pathways across planetary mass regimes, suggesting a transition from violent to quiescent dynamical histories with increasing planetary mass.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

DOUBLING THE SAMPLE OF ASTEROSEISMIC MASSES, RADII, AND AGES FOR TRANSITING PLANET SYSTEMS OBSERVED BY TESS

Samuel Grunblatt &
Caitlin Strafaci (1), Tobin Monroe (1), Nicholas Saunders (2)
University of Alabama; (1) University of Alabama; (2) Yale University

Despite the hundreds of thousands of asteroseismic detections from TESS, very few asteroseismic detections of planet host stars have been made. However, the availability of additional data from the extended missions of TESS has made the detection of solar-like asteroseismic signals easier. Here, we report asteroseismic solar-like oscillations detected in the TOI-2669 and TOI-4551 systems, doubling the number of planetary systems discovered by TESS with such signals. We use these newly measured asteroseismic constraints to redetermine stellar radii, masses, and ages in these systems, revealing that previous mass estimates were overestimated by 15%, and and ages reported were underestimated by 30-50%. This suggests that these systems, and by extension many of the TESS evolved planetary systems, are likely closer analogs to the future of our Solar System than previously believed. This implies that differences seen between this population and that of main sequence FGK stars are driven by system evolution rather than stellar mass differences.

THE T16 PLANET HUNT: 10,000 NEWLY IDENTIFIED TESS EXOPLANET CANDIDATES

Joshua Roth &
Joel D. Hartman, Gaspar A. Bakos
Princeton University; Princeton University

“The TESS mission is providing an ever-growing photometric data set, enabling the identification of large numbers of transiting planet candidates. However, most existing TESS planet searches focus on relatively bright stars (T<13.5 mag), largely due to the challenges associated with following up fainter targets. Nonetheless, planet occurrence rate studies suggest that a vast, largely unexplored population of planets around fainter stars exists and TESS should be able to detect them. Finding this population would open the door to statistically powerful studies of exoplanet demographics as well as the likely identification of rare, scientifically interesting planetary systems. The T16 project addresses this gap by producing tens of millions of uniformly detrended and systematics-corrected full-frame image light curves for all stars with T < 16 mag. Light curve production is complete for the primary TESS mission, yielding approximately 83 million light curves for Cycle 1 and 53 million for Cycle 2.
Using these T16 light curves, we conduct a semi-automated, machine-learning-assisted transit search across this full sample. The Cycle 1 search alone identifies 11,554 planet candidates orbiting stars down to T=16 with orbital periods between 0.5 and 27 days, including 10,091 new planet candidates. We validate our pipeline’s ability to identify real, previously unknown transiting planets through RV-follow-up observations on one of our Cycle 1 targets, TIC 183374187, confirming it as a hot Jupiter. Even without incorporating Cycle 2 data, our findings more than double the number of known TESS exoplanet candidates, and we expect a comparable number of additional candidates from Cycle 2.
In this talk, I will present the T16 transit search, discuss the resulting candidate population, and highlight how deep searches of TESS full-frame images can substantially expand the known exoplanet census and inform future demographic studies.”

ROOM 3
02/07 17:30–17:45

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

RESULTS FROM THE WIDE SEPARATION PLANETS IN TIME (WISPIT) SURVEY

Richelle van Capelleveen &
Matthew A. Kenworthy, Christian Ginski, Eric E. Mamajek, Tomas Stolker, Alexander J. Bohn, Ignas Snellen, Nienke van der Marel, Yapeng Zhang
Leiden Observatory, Leiden University

"The WIde Separation Planets In Time (WISPIT) survey is a VLT/SPHERE snapshot survey that targets 178 solar-mass stars with ages ranging from <5 to 20 Myr spanning the entire sky observable by VLT. Its goal is to detect and characterize wide-separation planetary mass companions. Published discoveries from this survey are the WISPIT 1 system and, most notably, the WISPIT 2 system.
WISPIT 1 is a ~16 Myr binary with a solar-type primary that hosts a ~10 Jupiter mass and ~5 Jupiter mass companion at separations of 338 au and 840 au, respectively, making it among the widest separation directly imaged planets to date. WISPIT 2 is another multi-planet system; this ~5 Myr version of our sun hosts a spectacular multi-ringed disk with two embedded planets. The discovery of WISPIT 2b marked the first unambiguous detection of a gap-carving embedded planet, which will likely make this system a benchmark for models of planet formation and planet-disk interactions for years to come. Both the WISPIT 1 and WISPIT 2 systems are novel and unexpected in their own way, and not only revealed new planets but also redefined where we should search for planets and how future direct imaging surveys should be designed.
The second epoch of 88 WISPIT survey targets will be observed between October 2025 and April 2026, so survey results may very well include the yet to be discovered WISPIT 3 system!"

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

NOT SO LONELY: HOT JUPITERS WITH NEAR-RESONANT COMPANIONS

Samuel Yee
University of California, Los Angeles

Most hot Jupiters are thought to be “lonely”, but an increasing number of hot Jupiters with close companions have now been discovered. As TESS continues to extend its observational baseline across the entire sky, it is gaining sensitivity to detecting nearby companions to hot Jupiters via transit timing variations. We present the results of a uniform search for TTVs in a magnitude-limited sample of hot Jupiters, including the discovery and photodynamical characterization of two new hot Jupiter systems that show large (~ 1 hr) transit timing and duration variations of the giant planet. This search provides new constraints on the frequency of hot Jupiters with close, non-transiting companions, and hints that such systems share similarities with other compact multi-planet systems.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

MISALIGNED COOL STARS WITH ``IN-BETWEEN" JUPITERS: SMOKING-GUN EVIDENCE FOR HIGH-E MIGRATION AND TIDAL REALIGNMENT

Songhu Wang &
Xian-Yu Wang
Indiana University; Josh Winn

In our own Solar System, the major planets all lie within a few degrees of the ecliptic, and the planetary plane is reasonably well aligned with the Sun's equator. Many exoplanet systems do not share this geometry. Most famously, hot Jupiters are often found on strongly spin–orbit misaligned orbits around hot stars, yet they are usually well aligned around cool, Sun-like hosts. This sharp temperature dependence raises a central question: are large misalignments a signature of hot-Jupiter delivery by high-eccentricity migration, or are hot stars intrinsically more misaligned across a broad range of planetary architectures? The most direct test, measuring spin–orbit angles for planets beyond hot Jupiters around truly hot stars, remains exceedingly sparse, leaving the two interpretations largely degenerate. In this talk, we present a smoking-gun test using cool-star systems. We identify a population of misaligned cool stars hosting "in-between" Jupiters: giant planets that are close enough to be delivered by high-eccentricity migration, but not close enough for tidal dissipation to realign the host star. These misaligned systems point to a high-eccentricity migration origin, in clear contrast to the longer-period warm Jupiters around cool stars, which are usually aligned and unlikely to be delivered by high-e migration. At the same time, their contrast with the mostly aligned, shorter-period hot Jupiters around cool stars supports tidal realignment once a giant planet is sufficiently close to its cool host. Together, these results strongly support a simple, unified picture for the origin and evolution of spin–orbit misalignments: high-eccentricity migration excites misalignment, and tides can erase it at the smallest separations.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

TWO POPULATIONS, TWO HISTORIES: ORBITAL ECCENTRICITIES OF EXOPLANETS AND BROWN DWARFS

Jonathan Roberts &
Jason Wang, GRAVITY Collabration
Northwestern University; Northwestern University

Our work explores the orbital architectures of substellar companions found at wide separations (3–420 AU) using a population-level analysis of 62 directly imaged companions, including 23 exoplanets and 39 brown dwarfs. A key part of this effort involved obtaining uniformly reduced VLTI/GRAVITY astrometry for 36 companions, which provides an improvement in precision and significantly reduces degeneracies in eccentricity and inclination. This is the first time eccentricity distributions for these populations are not prior-dependent, allowing us to recover consistent distributions for both exoplanet and brown dwarf populations regardless of the chosen prior. Consistent with previous findings, we observe a dichotomy: brown dwarfs tend to have higher-eccentricity orbits, while planetary-mass companions favor lower eccentricities, similar to closer-in giant planets. This ensemble behavior points to distinct dynamical pathways, with the higher eccentricities of brown dwarfs consistent with scattering or binary-like formation, and the lower eccentricities of planets supporting formation scenarios like core accretion or disk-driven migration.

EXOPLANETS
PORTO
2026

CONFERENCE ABSTRACTS E-BOOK

FRIDAY, JULY 03

PLANETARY EVOLUTION IN PROGRESS: THE FEATURE-RICH ATMOSPHERE OF THE 23 MYR SUB-NEPTUNE PROGENITOR V1298 TAU C

Matthew Murphy &
Adina Feinstein, Luis Welbanks, Girish Duvvuri, Saugata Barat, Ben Rackham, John Livingston, Hinna Shivkumar, Darryl Seligman, Ian Crossfield, Kevin France, Jonathan Lunine, Rafael Luque, Sagnick Mukherjee, Matthew Nixon, Sydney Petz, Michael Radica, Yoav Rotman, the KRONOS Collaboration

Michigan State University, Arizona State University, Vanderbilt University, MIT, National Astronomical Observatory of Japan, University of Amsterdam, Michigan State University, University of Kansas, University of Colorado Boulder, NASA JPL, Instituto de Astrofísica de Andalucía, Arizona State University, Arizona State University, Michigan State University, University of Chicago, Arizona State University

Atmospheric characterization of young transiting exoplanets offers a unique opportunity to probe how planetary atmospheres form and evolve. Young sub-Neptunes are particularly valuable as the mature sub-Neptune population appears diverse, raising the question of whether such diversity is primordial or a product of planetary evolution. The 23 Myr-old V1298 Tau system, which hosts four young, gaseous planets, is an ideal target for answering these questions. I will present the 1-5 micron transmission spectrum of the innermost planet, the sub-Neptune progenitor V1298 Tau c, observed using JWST/NIRISS and NIRSpec as part of the KRONOS program. Unlike the featureless spectra seen from many mature sub-Neptunes, our spectrum reveals many strong molecular features including water. Using these data, we tightly constrain V1298 Tau c's atmospheric metallicity, composition, and aerosol properties, and gain unprecedented insight into the primordial properties of sub-Neptunes. We also see evidence for significant atmospheric escape, providing clues for how V1298 Tau c's atmosphere may continue to evolve. I will discuss how these results compare to the other planets in the V1298 Tau system, and what they imply for the evolution of the most common type of planet in our Galaxy. Our observations also exhibit numerous starspot crossing events, and I will discuss how we are leveraging these to constrain the activity and surface properties of the young Sun-like star V1298 Tau. Altogether, our results are an exciting new window into the early-time properties of both sub-Neptunes and young Suns.

KRONOS: YOUNG SUB-NEPTUNES AND THE ORIGINS OF THE GALAXY'S MOST COMMON PLANETS

Luis Welbanks &
Adina Feinstein & The Kronos Collaboration
Arizona State University, Michigan State University & Other Institutions

"Sub-Neptunes are the most common planets we know of, yet for almost a decade, their atmospheric compositions remained elusive, with clouds and hazes hiding their molecular features. While JWST is changing our view of this population, one catch remains: if we are to understand the origins of sub-Neptunes, we must observe their younger, puffier progenitors—before their atmospheres become muted, ambiguous, and/or stripped.
I will present the first results from KRONOS, a JWST Cycle 3 Large Program surveying seven young sub-Neptunes across three multi-planet systems with panchromatic coverage from 0.6–5 μm (NIRISS/SOSS + NIRSpec/G395H). The survey was designed to understand how planets evolve in the first 300 Myr of their lifetimes, and how homogeneous individual systems and the young population of planets are.
From our survey, I will highlight the most surprising relationships we see across age and orbital separation, while addressing the challenges we've faced by observing active systems. I will discuss a surprising difference in atmospheric features and the early appearance of photochemical products in these atmospheres. Further, I will present our detection of atmospheric escape from our planets, something that is predicted but seemingly impossible to observe from the ground. Our early results can be used to inform formation pathways (water worlds vs gas dwarfs) of sub Neptunes and paths forward for understanding planetary formation and evolution with JWST."

THINKING OUTSIDE THE PLANE-PARALLEL BOX FOR YOUNG SUB-NEPTUNES

Frances Rigby &
James Owen
Imperial College London

In the era of JWST, high-precision transmission spectra are now available for a growing number of sub-Neptunes, shedding light on the present-day atmospheric compositions of these planets. Many of these spectra have been flat, with a degeneracy between possible high mean molecular weight or cloudy atmospheres. There remain key questions surrounding the sub-Neptune regime, including the formation and evolution processes that sculpt the population. Observations of young sub-Neptunes are an important avenue for understanding such processes, with distinct diagnostics of water-rich versus water-poor formation scenarios. The larger scale heights of young sub-Neptunes yield larger signals in transmission spectroscopy than mature sub-Neptunes, providing confident detections and reducing degeneracies from flat spectra. The recent observations of V1298 Tau b revealed strong detections of key molecules in its thick hydrogen-rich atmosphere, including CO2, CO, H2O, and CH4, the latter at significantly lower abundance than predicted by equilibrium chemistry. High internal temperatures (Tint ~ 600 K) and strong vertical mixing were invoked to explain these findings. However, this extreme Tint is difficult to reconcile with predictions of planetary evolution models and the planet's energy budget; the planet's bulk measurements and constraints on atmospheric escape require a low internal temperature consistent with boil-off. This therefore points to a problem with the assumptions behind either atmospheric or interior models. A common simplifying assumption in radiative transfer modelling is the plane-parallel set-up, valid for atmospheric scale heights much less than the planetary radius – a condition that is violated for the highly extended atmospheres of young sub-Neptunes. This could have significant implications for interpreting the thermal structure and chemistry of their atmospheres and interiors. We explore the effect of relaxing this assumption on the inferred Tint and predicted methane abundances for young sub-Neptunes, demonstrated using V1298 Tau b. Using a radiative transfer model configured in both plane-parallel and spherical coordinates we compare the resulting atmospheric pressure-temperature profiles for equivalent internal luminosities. We proceed to consider the implications of using spherical coordinates on models of atmospheric chemistry, by modifying the photochemical code VULCAN, and self-consistently including our updated temperature structures. Due to geometric dilution, a spherical atmosphere has a higher temperature at deeper pressures for fixed internal temperature compared to a plane-parallel one, suppressing the methane. Young sub-Neptunes are crucial windows into the origins of the most abundant planetary population and closely linked to the origin of the radius valley. Our results demonstrate the importance of challenging modelling assumptions when interpreting observations of young and low-gravity exoplanets with JWST.

COOL WORLDS: UNLOCKING THE SECRETS OF TWO FRIGID ATMOSPHERES USING JWST/MIRI

Helena Kühnle
ETH Zurich

"Cold worlds beyond our Solar System with effective temperatures below 500K have long been poorly characterised. Now, with JWST/MIRI we can probe their atmospheric structure and composition in unprecedented detail with medium resolution mid infrared spectroscopy. Leveraging the power of direct imaging, we obtain high signal to noise ratio measurements, allowing us to reveal the details of their cold atmospheres. Specifically, we aim to understand whether water condenses out and forms water ice clouds. Also, it allows us to search for unexpected molecules and isotopologues of the dominant trace gases, ammonia, water, and methane.

In this talk, I will put two of the coldest objects ever observed in relation: the coldest brown dwarf, WISE 0855, with a temperature of ~275K, and one of the coldest planetary mass companions, COCONUTS-2b with a temperature of ~480K. Their secrets on the water condensation, clouds and isotopologue composition are unlocked using atmospheric retrieval analyses with petitRADTRANS and publicly available self-consistent grid models.

By varying the abundance profiles, we detect a depletion of water in the upper atmosphere of WISE0855 and connect it to the condensation of water. First ever detected isotopologues in cold gas giants provide us with valuable information about the early stages of their formation process – and keep us puzzled at the same time. Both worlds seem to be different at first, in terms of effective temperature, and the fact that one is bound, and the other is not. However, their chemistry and mass regime seem surprisingly similar. Thus, this challenges the idea to use atmospheric composition as a tracer for possible formation scenarios.

Learned characteristics from such cold atmospheres are a crucial stepping stone to improve our understanding of closer-in gas giant atmospheres. Isotope ratios are important to compare to those of the host stars. Significant differences indicate another formation scenario compared to a binary-like formation scenario. Thus, acquiring more data on such cold targets will be crucial to identify potential links between composition and bulk parameter. In the future, elemental and isotopic ratio trends will help to link to their respective formation histories."

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

THE CARBON KEY: FIRST DETAILED CHEMICAL INVENTORY OF THE STEAM WORLD PLANET GJ 9827 D

Caroline Piaulet-Ghorayeb &
Marie-Luise Steinmeyer, Nicole Gromek, Eva-Maria Ahrer, Caroline Dorn, Björn Benneke, Hilke Schlichting, Ryan Cloutier, Bo Peng, Jeehyun Yang, Michael Radica, Luis Welbanks, and the Water Worlds JWST Program team
Department of Astronomy & Astrophysics, University of Chicago

"In recent years, JWST's sensitivity has opened a "small sub-Neptune opportunity", paving the way for atmospheric reconnaissance on rocky exo-Earths. Indeed, the atmospheres of the smallest sub-Neptunes are ideally puffy for chemical characterization, but thin enough to carry the imprints of both chemical exchanges with their interiors and atmospheric escape over Gyr timescales. While sub-Neptune mantles may remain molten, resulting in chemical exchanges between the interior and the atmosphere, carbon species are much less soluble than water in the silicate melt, making the atmospheric abundances of carbon species more reliable tracers of planetary elemental makeup relative to water.
The 2-Earth-radii warm (680 K) planet GJ 9827d is the smallest sub-Neptune to be chemically characterized with JWST to date, with NIRISS/SOSS revealing its one-of-a-kind "steam world" high-metallicity, water-rich atmosphere. However, the wavelength coverage did not yet constrain other major carbon-, oxygen-, and potential sulfur-bearing species. I will present new results from two additional JWST NIRSpec G395H transit observations of GJ 9827 d. The relative abundances of CH4 and CO2 relative to water surprisingly still suggest a water-rich atmosphere, with a deficit in atmospheric carbon compared to expectations from magma ocean-atmosphere interactions. I will discuss this finding in the context of our chemical inventory of the star's composition, modeling of the structure and chemistry of GJ 9827 d's interior, as well as the possibility of graphite precipitation, early carbon loss, or mantle solidification. The carbon-poor chemistry of GJ 9827 d is at odds with other well-characterized larger sub-Neptunes, suggesting a different formation pathway in line with its unique water-rich atmosphere."

MAIN ROOM
03/07 10:15–10:30

TOPIC 3: TOWARDS THEIR DETAILED CHARACTERISATION (INTERIOR MODELS, ATMOSPHERES, ASTROBIOLOGY, …)

NEAR-INFRARED SPECTRA OF THE HR 8799 PLANETS WITH JWST

Evert Nasedkin

Trinity College Dublin

The iconic HR 8799 planets are often used as a benchmark against which we can compare the rest of the directly imaged exoplanet population. With four planets sharing a formation history, they present the ideal case to understand how these giant, widely separated planets form. However, recent results identifying unusually high metallicities from Nasedkin et al 2024 and Ruffio et al 2026 have demonstrated that rather than being benchmark objects, they are more likely to be outliers representing the extreme end of planet formation. In order to understand both their current atmospheric state and how they arrived there, it is critical to understand the chemical composition and thermal structure of their atmospheres, which has proven challenging due the limitations of ground-based observations. In this talk I will present new spectra of all four planets obtained through JWST GO 7268, together with preliminary results of the analysis of these spectra. These are among the first high-contrast observations with the NIRSpec IFU at <3 micron. Our atmospheric retrievals provide critical constraints on the metallicity, C/O ratio, and surface gravity of these objects, resolving the tension between different ground-based measurements. Understanding this system will allow us to place limits on the possibilities of different planet formation scenarios, and will provide a path to follow for future analyses of the directly imaged planet population with JWST.

LHS 3844 B'S SURFACE: INSIGHTS FROM THE HIGHEST SNR EMISSION SPECTRUM OF ANY ROCKY EXOPLANET

Kimberly Paragas &
Heather Knutson (1), Renyu Hu (2), Sebastian Zieba (3), Laura Kreidberg (4), Bethany Ehlmann (1)

(1) Division of Geological and Planetary Sciences, California Institute of Technology, (2) Department of Astronomy and Astrophysics, The Pennsylvania State University, University Park, (3) Center for Astrophysics, Harvard & Smithsonian, (4) Max-Planck-Institut für Astronomie

JWST provides a unique opportunity to spectroscopically characterize the surface compositions of terrestrial exoplanets for the first time. Close-in, rocky planets orbiting M dwarfs are ideal targets for these studies, as recent Spitzer and JWST measurements have shown that many have little to no atmosphere. LHS 3844 b is an ultra short period (P = 11 hours) bare-rock super-Earth (Rp = 1.3 Rearth) orbiting a 3000 K M dwarf, and is one of the most favorable targets available for these studies. We present a first look at its combined NIRSpec G395H and MIRI LRS emission spectrum, which we construct from a total of 14 (9 of which were recently taken) separate eclipse observations. For the first time, our data provide the sensitivity to detect the Christiansen feature (an indication of the presence of silicate rocks) and the transparency feature (whose presence or absence reveals information about the surface's grain size independent of composition). This is the highest SNR emission spectrum for any rocky exoplanet thus far, with a median precision of 26 ppm across 12 MIRI wavelength bins. The MIRI part of the spectrum is well-fit by a 998±4 K blackbody, with no significant deviations (χ^2_red = 0.90). We additionally demonstrate how the inclusion of the NIRSpec G395H observations significantly increases our sensitivity to surface spectral features. We discuss the corresponding implications for this planet's surface mineralogy, including the potential role of near-surface temperature gradients and space weathering in suppressing the depth of any surface spectral features. LHS 3844 b is the highest ESM target of all bare-rock planets with solid dayside surfaces (Teq < 1000 K), making this spectrum a foundational dataset for advancing exo-geology studies.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

WEATHER ON OTHER WORLDS: JWST OBSERVES SILICATE CLOUD VARIABILITY ON A GIANT EXOPLANET

Niall Whiteford &
Elisabeth Matthews (2); Daphne Broski-Laing (3); Yifan Zhou (3); Beth Biller (4); Jackie Faherty (1); Xianyu Tan (5); Evert Nasedkin (6); Johanna Vos (7); Melanie Rowland (1); Emily Calamari (1);

American Museum of Natural History, (2) Max Planck Institute for Astronomy; (3) University of Virginia; (4) University of Edinburgh; (5) Shanghai Jiao Tong University; (6)Trinity College Dublin;

Why are the atmospheres of imaged exoplanets so variable? For several decades we have observed significant photometric variability from numerous giant exoplanets, and their brown dwarf cousins, while debating on the fundamental cause. Model predictions have been unclear on whether the mechanism of variability is driven by clouds, chemistry, auroral activity, an interior process or a process yet to be identified. To date, no observational evidence has led to a confident conclusion on one mechanism or another. However, in this talk I will present results from a 24-hour campaign using JWST as a weather satellite to spectrally monitor VHS 1256 b, which yielded clear evidence that clouds drive variability. Using interleaved NIRSpec/Prism, NIRSpec/G395H, and MIRI/MRS observations, we show a clear anti-correlation in the light curves between silicate cloud absorption bands at both 10 and 20 microns and the molecular features of H2O, CO, and CH4. In other words, the less clouds there are the stronger molecular absorption is and vice versa. General Circulation Models (GCMs) predict our observations could be the result of cloudy superstorms rotating in and out of view. This is the first definitive observational evidence that clouds are the driving force behind the commonly seen variability of imaged exoplanets. This is also the first detection of the long predicted 20 micron secondary silicate feature, crucially opening the door to break cloud model degeneracies. This work, employing our novel and uniquely informative observing strategy, dawns a new era of probing the weather and climates of worlds beyond our solar shores.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

FIRST RESULTS FROM THE JWST EXOPLANET GRAND TOUR SPECTROSCOPIC SURVEY

Carlos Gascon Alvarez &
David K. Sing, Mercedes Lopez Morales & The Grand Tour Team
John Hopkins University, Space Telescope Science Institute

The unprecedented precision of JWST is transforming exoplanet atmosphere studies, but fully exploiting this capability requires a comparative, population-level perspective. We present the first atmospheric results from the JWST Exoplanet Grand Tour Spectroscopic Survey (PI: Sing), a 142-hour coordinated JWST–HST program aimed at characterizing the atmospheres of giant exoplanets from Neptune to Jupiter sizes. The survey targets a diverse sample of highly irradiated planets spanning a wide range of temperatures, providing a uniform dataset for comparative atmospheric studies early in the JWST era. We present new transmission spectra for multiple planets in the survey, including the methane-rich WASP-80b, the limb-asymmetric system WASP-94b, and several other hot and ultra-hot Jupiters, such as KELT-7b, HAT-P-30b, and WASP-76b. For each planet, we unveil the measured transmission spectrum and present results from atmospheric retrieval analyses, constraining molecular abundances, cloud properties, and atmospheric structure. Beyond individual targets, we combine these new observations with archival datasets to place the results in a population-level context. These first results demonstrate how coordinated JWST–HST surveys enable comparative exoplanet atmosphere studies, providing the critical framework needed to interpret the rapidly growing number of high-precision single-planet JWST observations.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

A NEW MOLECULE ON A TEMPERATE GIANT ORBITING A LATE M DWARF

Jeehyun Yang &
Michael Zhang
University of Chicago

TOI 6894 is the smallest star known to host a transiting giant planet. The Jupiter-sized TOI 6894b has an enormous 15% transit depth and a temperature of Teq=410 K. We measure its transmission spectrum with NIRSpec/PRISM, obtaining an exquisite spectrum with minimal stellar contamination that shows prominent absorption features from CH4, CO2, NH3, and a never-before-seen molecule that challenges our understanding of photochemistry. We analyze the planet's nitrogen inventory, leveraging its ammonia-favorable temperature, large transit depth, and low gravity. We report separate temperatures and chemical compositions for the two limbs, in the first detection of limb asymmetry for a planet this cold. Finally, we piece together the clues to speculate on how a planet this massive could have formed around such a small star.

ESPRESSO CHARACTERIZES THE SMALL TRANSITING EXOPLANET POPULATION WITH EXTREME PRECISION RADIAL VELOCITIES

Melissa Hobson &
F. Bouchy, B. Lavie, C. Lovis, and the ESPRESSO GTO consortium
Observatoire de Genève / IPAG, Grenoble

"The most common planets in the Galaxy are super-Earths and sub-Neptunes. These planets, with masses and radii between those of Earth and Neptune, are intriguing as we do not find such planets in the Solar System, raising the question of what their likely compositions are. Likewise, they are the most promising candidates for habitability. However, due to their small size and low mass, they are also the hardest planets to detect and characterize, requiring the best possible facilities.

The ESPRESSO spectrograph at the Very Large Telescope in Chile is the leading instrument for the characterization of the lowest-mass planets with extreme precision radial velocity (EPRV), thanks to its exquisite 10 cm/s instrumental RV precision and the large collection area of the VLT, which enables the acquisition of high signal-to-noise spectra even for fainter host stars. Between 2018 and 2023, the ESPRESSO consortium followed up some 50 stars hosting small transiting planet candidates from K2 and TESS, as part of the ESPRESSO Guaranteed Time Observations (GTO).

In this contribution, we will give a global overview of the 54 planets in 23 systems confirmed by this program, which range from super-Mercuries through super-Earths and water worlds to sub-Neptunes. These planets represent a significant addition to the precisely-characterized small planet population. We will highlight emerging trends in the overall population, such as:

– an insolation-dependent mass threshold between rocky and volatile rich planets;
– the clear emergence of a group of high-mass rocky ""stripped core"" planets at high insolation;
– an increasing planet mass with higher stellar metallicity.

We also compare planet masses to typical protoplanetary disks, finding these planets must form either early in the disk's lifetime, with high formation efficiency, or preferentially in massive disks.

Finally, we will discuss the lessons learned from this program in terms of observing and analysis strategies. In the context of the upcoming PLATO mission, this is vital knowledge for the follow-up of the Earth-sized planet candidates that are PLATO's principal objective."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

DIVING INTO THE PLANETARY SYSTEM OF PROXIMA WITH NIRPS

Alejandro Suárez Mascareño &
NIRPS Consortium
University of La Laguna

"The discovery of an Earth-like planet in the habitable zone of our closest neighbor, Proxima Centauri, was a landmark moment in exoplanetary science. It demonstrated that even the nearest star to the Sun could host a potentially habitable rocky planet. Since then, Proxima has been the focus of extensive radial velocity (RV) monitoring, primarily with HARPS and ESPRESSO, to confirm its planetary system and search for additional companions.
We present the results of the Guaranteed Time Observations of NIRPS, the new near-infrared RV spectrograph at the ESO 3.6m telescope in La Silla. Our findings reaffirm the presence of Proxima b and demonstrate that sub-meter-per-second RV precision can be achieved in the near-infrared. Furthermore, the data shows evidence supporting the presence of the sub-Earth Proxima d. The precision of NIRPS, with residual RV scatter of just 80 cm/s, showcases its potential to detect low-amplitude planetary signals around M-dwarfs.
Combining the NIRPS-GTO data with the archival historical spectroscopic and photometric observations, we provide full confirmation of Proxima d and demonstrate that its parameters are stable over time and against change of instrument. By performing a global model that accounts for instrumental systematics, the stellar magnetic cycle, stellar rotation, and the planets, within a multi-dimensional GP framework, we measure the minimum masses of Proxima b, and d, to be 1.055 +- 0.055 Me, and 0.260 +- 0.038 Me, respectively."

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

FORMING WATER-RICH PLANETS FROM DRY BUILDING BLOCKS

Allona Vazan

Astrophysics Reseach Center (ARCO), Open University of Israel

Water-rich sub-Neptunes are commonly assumed to form beyond the water ice line and later migrate inward. However, recent high-pressure experiments show that reactions between hydrogen and silicate melt at core-envelope boundary conditions can efficiently produce large amounts of water. The thermal and structural evolution of such planets shows efficient redistribution of the produced water into both the gaseous envelope and the molten core across a wide range of planetary masses and envelope fractions. These findings demonstrate that planets formed from nominally dry building blocks can evolve into water-rich worlds without the direct accretion of water ice. We further explore the conditions under which water production can persist, identifying key dependencies on planetary properties. The resulting diversity of reaction efficiencies naturally leads to a broad range of water abundances among hydrogen-rich planets. We conclude that the detection of abundant water in exoplanet atmospheres does not uniquely imply formation beyond the ice line, but instead points to an evolutionary link between hydrogen-rich and water-rich planets.

TOPIC 1: PRESENT DAY RESULTS IN EXOPLANET RESEARCH (SETTING THE STAGE)

REVEALING UNCOMMON GAS GIANTS TRANSITING LOW-MASS STARS

Yolanda Frensch
Instituto de Astrofísica e Ciências do Espaço

“The existence of gas giants around low-mass stars challenges planet formation theories. It raises the question of whether a stellar-mass threshold exists below which giant-planet formation becomes impossible. We present results from TESS follow-up programs targeting gas giants orbiting low-mass stars, based on radial-velocity observations with CORALIE and NIRPS. The sample includes the recently published systems TOI-2969 b, TOI-2989 b, TOI-3288 b, TOI-4666 b, and TOI-5300 b, as well as several additional in-prep targets.
The combined sample reveals population-level trends. In particular, planetary mass decreases with decreasing stellar effective temperature: late M dwarfs preferentially host lower-mass giant planets compared to early M dwarfs. Systems hosting more massive gas giants that deviate from this trend are predominantly metal-rich. Moreover, we find a higher binary fraction among low-mass stars hosting gas giants, suggesting that stellar companions may facilitate giant-planet formation in these systems.
Together, these observations suggest that metallicity and stellar multiplicity play a key role in enabling giant-planet formation around the lowest stellar masses.”

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