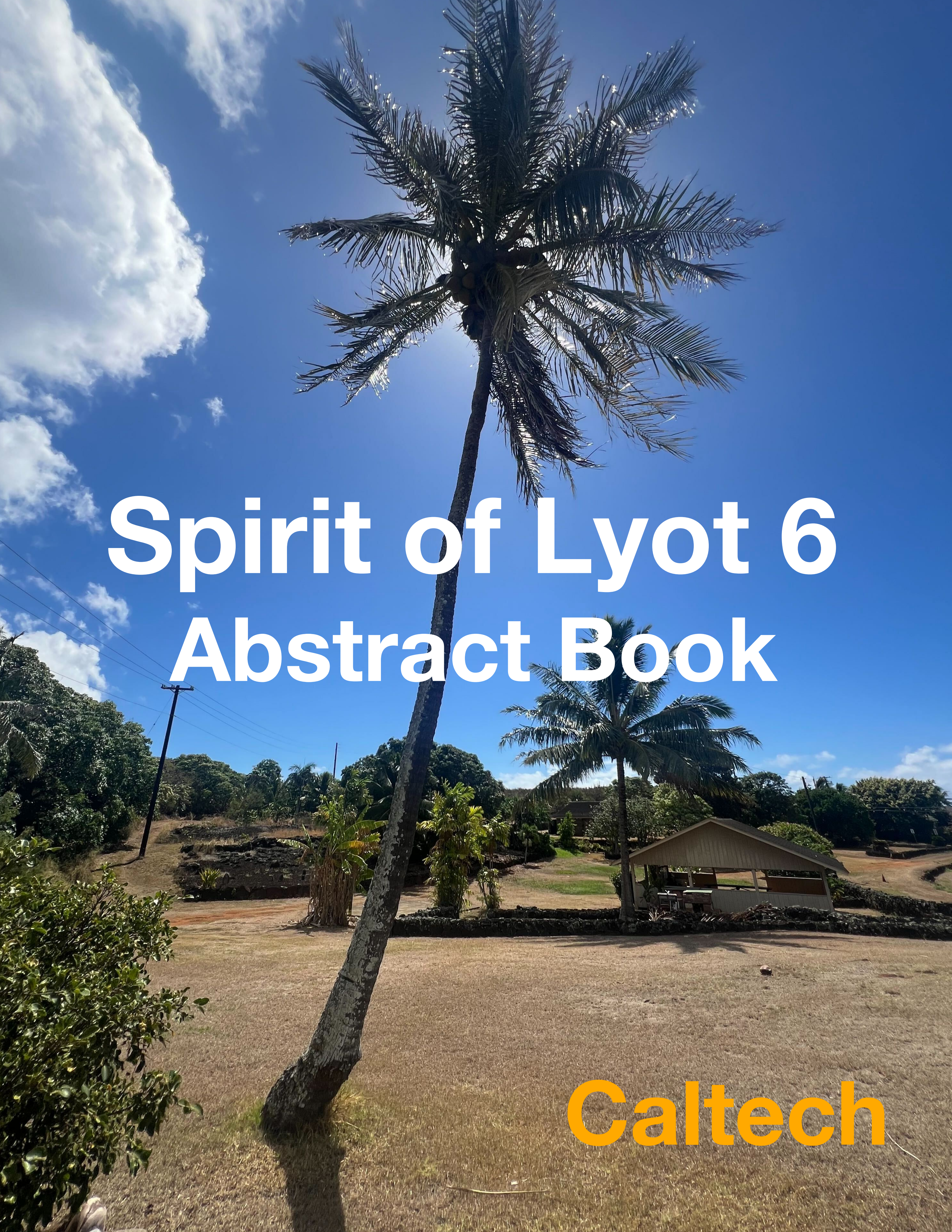

Spirit of Lyot 6
Abstract Book

Caltech

Agenda


C (subtracted)
Cb
B
A (hidden)
C
Cb
GJ 504b
Residual scattered starlight
Location of star (masked)
Size of Neptune's orbit
1 arcsecond
1.6 billion miles
2.6 billion km
ALMA
SPHERE/VLT
MUSE/VLT
PDS 70 c
PDS 70 b
14 Her
C
A
B
A
b

Monday 2025 February 02		
Time		
08:00-09:00	*Doors Open*	
	JWST Science and Instrumentation	
09:00-09:45	**Marshall Perrin (STScI)**	**High Contrast Imaging and Spectroscopy with JWST: Methods, Performances, and Lessons for the Future**
09:45-10:00	Aarynn Carter (STScI)	Emerging Demographics of Cold Sub-Jupiters from JWST High-Contrast Imaging Surveys
10:00-10:15	James Mang (UT Austin)	Jupiter Analogs in Sight: Modeling the Coldest Directly-Imaged Atmospheres Observed with JWST
10:15-10:45	*Coffee Break*	
10:45-11:00	Elisabeth Matthews (MPIA)	Imaging cold exoplanets with JWST: a case study of Eps Ind Ab
11:00-11:15	Alexander Bogdan Madurowicz (STScI)	Direct spectroscopy of cool exoplanets and brown dwarfs with JWST / NIRSpec
11:15-11:30	Jerry Xuan (UCLA)	Metal enrichment in both volatile (C, O, N) and refractory (S) elements for giant planets in HR 8799 and AF Lep
11:30-11:45	Arthur Daniel Adams (University of Virginia)	Mapping Exoplanets and Brown Dwarfs across Space and Time
11:45-12:00	Jingwen Zhang (UCSB)	Finding the great sculptors: A Renaissance in Planet Disk Dynamics
12:00-13:00	*Lunch (On Your Own)*	
13:00-14:00	*Poster Session 1*	
14:00-14:45	**Christine Chen (STScI)**	**Witnessing the Formation and Evolution of Planetary Systems**
14:45-15:00	Andras Gaspar (University of Arizona)	Results from the JWST NIRCam and MIRI GTO Debris Disks programs
15:00-15:15	Katie Crotts (STScI)	Direct imaging and spectroscopy of the Beta Pictoris disk structure with JWST/MIRI
15:15-15:45	*Coffee Break*	
15:45-16:00	Claire Finley (UT Austin)	Accretion and Circumplanetary Disk Properties of a Wide Orbit Planet with HST and JWST
16:00-16:15	Ya Lin-Wu (National Taiwan Normal University)	New perspectives on Disks around Planetary-mass Companions from JWST/MIRI
16:15-16:30	Gabriele Cugno (University of Zurich)	A carbon-rich disk surrounding a planetary-mass companion
16:30-16:45	Raphael Bendahan-West (University of Exeter)	Extreme dust size segregation in HD 21997: Constraining the origin of gas in debris discs with JWST and ALMA
16:45-17:00	Paul Kalas (UC Berkeley)	Fireworks around Fomalhaut: Planetesimal collisions directly imaged with Hubble
17:00-17:30	*Adjourn*	
17:30	*Opening Reception (Welcome to All, Drinks and Light Snacks)*	

Tuesday 2025 February 03		
Time		
08:00-09:00	*Doors Open*	
	Synergies and Post-Processing	
09:00-09:45	**Emily Rickman (STScI)**	**Comprehensively characterizing companions through a multi-measurement approach**
09:45-10:00	Thayne M. Currie (UT San Antonio)	First Results from the OASIS Survey for Discovering and Characterizing Extrasolar Planets by Direct Imaging and Astrometry
10:00-10:15	Kyle Franson (UCSC)	Astrometric Accelerations as Dynamical Beacons: Efficiently Imaging Planets Around Young Accelerating Stars
10:15-10:45	*Coffee Break*	
10:45-11:00	Markus Johannes Bonse (ESO)	Use the 4S: A systematic re-analysis of VLT/NaCo data with Explainable Machine Learning
11:00-11:15	Carles Cantero (Observatoire de Geneve)	SpeckleNet: a generative deep learning framework for speckle modeling
11:15-11:30	Rodrigo Ferrer-Chavez (Northwestern University)	From data-drive to physics-based: exoplanet imaging via differentiable optical models
11:30-11:45	Louis Desdoigts (Leiden Observatory)	AMIGO and the James Webb Interferometer
11:45-12:00	Kaitlyn Hessel (University of Victoria)	Machine Learning & Coherent Differential Imaging with SPIDERS
12:00-13:00	*Lunch (On Your Own) OR Early-Career Researcher Lunch*	
13:00-14:00	*Poster Session 1*	
14:00-14:45	**JB Ruffio (UCSD)**	**Data analysis techniques in high-contrast imaging**
14:45-15:00	Jason Wang (Northwestern University)	Lessons Learned on Combining High-Contrast Imaging with High-Resolution Spectroscopy after 7 years of KPIC
15:00-15:15	Alexis Bidot (STScI)	Enabling medium-contrast direct spectroscopy of exoplanets using MIRI/MRS via forward modeling.
15:15-15:45	*Coffee Break*	
15:45-16:00	Allan Denis (LAM, Marseille)	Characterisation of giant planets at high spectral resolution: recent results from VLT/HiRISE
16:00-16:15	Amanda Mia Chavez (Northwestern University)	Orbital Analysis of HR8799 Using GRAVITY High Precision Astrometry
16:15-16:30	Briley Lynn Lewis (UCSB)	GPU-Enabled Debris Disk Modeling with GRaTeR-JAX
16:30-16:45	Adam K Taras (Leiden Observatory)	Nulling interferometry at the VLTI with Asgard
16:45-17:00	Katelyn Horstman (Caltech)	Searching for exo-satellites and brown dwarf binaries using the Keck Planet Imager and Characterizer (KPIC)
17:00-17:30	*Adjourn*	

Wednesday 2025 February 04		
Time		
08:00-09:00	*Doors Open*	
	Roman Coronagraph and other New Missions	
09:00-09:45	**Bertrand Mennesson (NASA JPL)**	**The Roman Coronagraph and Its applicability to HWO**
09:45-10:00	Eric Cady (NASA JPL)	The Commissioning Plan for the Roman Space Telescope Coronagraph Instrument
10:00-10:15	Schuyler Wolff (University of Arizona)	Designing the Observation Phase of the Nancy Grace Roman Space Telescope Coronagraph Instrument
10:15-10:45	*Coffee Break*	
10:45-11:00	Justin Hom (University of Arizona)	CorGI-REx, the bright reference star vetting campaign for the Roman Coronagraph and beyond
11:00-11:15	Alexis Lau (LAM, Marseille)	High Order Dithering on HiCAT testbed: extending JWST small grid dithering strategies on Roman CGI
11:15-11:30	Saavidra Perera (UCSD)	Socio-Demographic Insights into the Exoplanet Direct Imaging Community: A Follow-Up Study
11:30-11:45	Christopher Mendillo (UMass Lowell)	PICTURE-D First Flight Results
11:45-12:00	Raphael Rougeot (ESA)	Proba-3 precision formation flying mission: an in-orbit success
Free Time		

Thursday 2025 February 05		
Time		
08:00-09:00	*Doors Open*	
	Ground-Based Science and Instrumentation	
09:00-09:45	**Jonathan Fortney (UCSC)**	**Exoplanet Atmosphere Models: Strengths, Weaknesses, and the Future**
09:45-10:00	Richelle Felicia van Capelleveen (Leiden)	Results from the WIde Separation Planets In Time (WISPIT) survey
10:00-10:15	Tomas Stolker (Leiden)	Direct imaging discovery of a young giant planet orbiting on solar system scales
10:15-10:45	*Coffee Break*	
10:45-11:00	Jonathan Roberts (Northwestern)	Two Populations, Two Histories: Orbital Eccentricities of Exoplanets and Brown Dwarfs
11:00-11:15	Miles Lucas (University of Arizona)	Dynamical Analysis of the HD 169142 Planet-Forming Disk
11:15-11:30	Jinlin Li (Kavli Institute, Peking University)	Tracing Shadow Variability in Protoplanetary Disks with Multi-Epoch Scattered-Light Imaging
11:30-11:45	Jared Males (Steward Observatory)	GMagAO-X: High-Contrast Imaging at First-Light of GMT
11:45-12:00	Laird Close (Steward Observatory)	A Review of Accreting Exoplanet (Protoplanet) High-Contrast H-alpha Direct Imaging Science with Magellan/MagAO-X and a Look to the Future with GMT/GMagAO-X
12:00-13:00	*Lunch (On Your Own)*	
13:00-14:00	*Poster Session 2*	
14:00-14:45	**Markus Kasper (ESO)**	**Extreme Adaptive Optics on the path to the ELT(s)**
14:45-15:00	Nathalie Jones (Northwestern)	Old Data, New Planet: Finding Candidate Companions from the Gemini Planet Imager Exoplanet Survey
15:00-15:15	Bruce Macintosh (UC Observatories)	The Gemini Planet Imager and the Road to GPI 2
15:15-15:45	*Coffee Break*	
15:45-16:00	Olivier Absil (University of Liège)	Getting ready for early high-contrast imaging at the ELT with METIS
16:00-16:15	Paulina Palma-Bifani (LIRA, Observatoire de Paris)	Exoplanet science with MICADO at the ELT: Simulations, challenges, and first-light strategies
16:15-16:30	Anthony Boccaletti (LIRA, Observatoire de Paris)	Upgrading SPHERE with the second stage AO system SAXO+: a technology demonstrator for PCS
16:30-16:45	Julien Lozi (Subaru)	SCExAO's evolution toward multi-stage AO correction & astrophotonics
16:45-17:00	Maissa Salama (UCSC)	Exoplanet Imaging with Large Segmented Telescopes: On-Sky Results from using Keck as a Testbed for Next Generation Telescopes
17:00-18:00	*Adjourn*	
18:00	*Optional Conference Dinner (Please Register)*	

Friday 2025 February 06		
Time		
08:00-09:00	*Doors Open*	
	Emerging Technologies and HWO	
09:00-09:45	**Chris Stark (NASA Goddard)**	**The Habitable Worlds Observatory and the Search for Other Earths**
09:45-10:00	Remi Soummer (STScI)	Towards a system-level coronagraphic demonstration for the Habitable Worlds Observatory
10:00-10:15	Saraswathi Kalyani Subramanian (University of Arizona)	Performance evaluation of ultraviolet coronagraphs for the Habitable Worlds Observatory
10:15-10:45	*Coffee Break*	
10:45-11:00	Christian Marois (National Research Council of Canada)	SPIDERS Habitable Worlds Observatory Experiment: Can we Reach 10^10 Contrast (from ~10^7) with CDI and R10,000 SDI Post-Processing?
11:00-11:15	Caleb Baker (NASA JPL)	For a Few Photons More: Design and Development Updates for HWO Testbeds at JPL
11:15-11:30	Rico Landman (NOVA)	SUPPPPRESS: Developing low-leakage liquid-crystal vector vortex coronagraphs for space-based exoplanet imaging
11:30-11:45	Rachel Morgan (SETI/NASA Ames)	Laboratory Update for the AstroPIC Integrated Photonic Coronagraph
11:45-12:00	Joshua Liberman (University of Arizona)	Lab Demonstration of the Spatially-Clipped Self-Coherent Camera
12:00-13:00	*Lunch (On Your Own)*	
13:00-14:00	*Poster Session 2*	
14:00-14:45	**Sebastiaan Haffert (Leiden)**	**Emerging technologies that bridge the HCI technology gap**
14:45-15:15	Technology panel	
15:15-15:45	*Coffee Break*	
15:45-16:00	J. Kent Wallace (NASA JPL)	Dual-purpose Focal Plane Masks for Simultaneous Wavefront Sensing and High-contrast Imaging
16:00-16:15	Jalo Aarni Johannes Nousiainen (ESO)	Reinforcement learning for wavefront control: from WFS control to focal plane and from numerical simulations to lab and on-sky with PAPYRUS @ OHP
16:15-16:30	Yoo Jung Kim (UCLA)	On-sky demonstration of subdiffraction-limited measurements using a photonic lantern
16:30-16:45	Skyler Palatnick (UCSB)	4 years in metasurface development for exoplanet imaging at UC Santa Barbara
16:45-17:00	Philippe Priolet (IPAG, Grenoble, France)	Multiwavelength Interferometric Observations of Hot Dust in Three Extreme Debris Disks: HD172555, HD113766, and Eta Corvi
17:00-17:30	*Adjourn*	

Poster Session 1

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Avsar	Arin	Studying Massive Collisions in Exo-Kuiper Belts with Multi-Epoch Coronagraphy	3
Baburaj	Aneesh	First Spectroscopic Observations of Cold Planetary-mass Companion GJ 504 b with JWST/NIRSpec reveal high metal enrichment	4
Balmer	William	Colder, closer: Pushing the limits of JWST Coronagraphy	5
Beichman	Charles	Will Gaia DR4 Reveal New Targets for Roman/CGI	6
Bendek	Eduardo	Following Up Alpha Cen Ab Planet Candidate using the Roman Space Telescope Coronagraph	7
Blakely	Dori	The Disk Connection: Detecting Planets Around Disk-Hosting Stars with Hipparcos and Gaia Astrometry	8
Boccaletti	Anthony	Mid-infrared images of iconic directly imaged systems with JWST/MIRI.	9
Bovie	Danielle	Characterizing Massive Planets and Brown Dwarfs with High-Contrast Imaging and Precision Astrometry	10
Bowens-Rubin	Rachel	NIRCam yells at cloud: How non-chronographic MIRI imaging can directly detect exoplanets as cold as Saturn and Jupiter that other modes might miss	11
Bowler	Brendan	Accretion Light Echoes and Halpha Variability of a Protoplanet Candidate	12
Bryden	Geoffrey	JWST/NIRCam imaging of the HR 8799 planetary system	13
Cantero	Carles	New substellar candidates identified with deep learning in the large-scale SHINE direct imaging survey	14
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Ceva	William	High contrast imaging of substellar companions that correspond to long term trends in over 25 years of RV data	16
Choquet	Elodie	ESCAPE: investigating active observing and post-processing methods for Roman and HWO	17
Costa	Jean	Construction of a Data Processing Algorithm for Light Curves in Exoplanet Detection via the Transit Method	18
Courtoux	Margot	Detection and characterisation of protoplanets with JWST/MIRI	19
Crotts	Katie	The First Saturn Analog: Exploration of the TWA 7 Planet–Disk System with JWST NIRCam	20
Cugno	Gabriele	Direct Measurement of Extinction in a Planet-Hosting Gap	21
Darcis	Michiel	Wavefront Sensing in Colour Using the Gradient Descent Reconstructor and Microwave Kinetic Inductance Detectors (MKIDs)	22
Debes	John	Cold Planets Around White Dwarfs with JWST	23
Delaye	Lukas	Simulated parametric study of coherent differential imaging for exoplanet detection with SPHERE(+).	24
Demars	Dorian	New multi-epoch H-alpha monitoring observations of PDS 70 b and c	25
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Girard	Julien	Ground/space complementarity in the direct imaging of exoplanetary systems, a review	28
Godoy	Nicolas	The JWST/MIRI view of HR 2562 b and κ And b	29
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Poster Session 2

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Oral Presentations

1 Oral Presentations

Emerging Demographics of Cold Sub-Jupiters from JWST High-Contrast Imaging Surveys
Aarynn Carter (STScI)

The high-contrast imaging capabilities of JWST have dramatically expanded our ability to directly detect exoplanets. With its exquisite stability and infrared sensitivity, JWST has enabled the detection and characterization of the coldest known exoplanets, and the discovery of the lowest mass imaged planet to date. While striking results in isolation, their impact is better measured in terms of the broader questions we can now begin to answer: "How common are Saturn mass planets at wide separations?", and "What are the dominant features and diversity across cold gas giant atmospheres?". In this talk, I will present results from three combined JWST NIRCam 2.0+4.4 micron imaging surveys of nearby associations and young moving groups, totaling ∼170 stars of spectral type A through M (GO4050, GO5835, SURVEY6005). Our surveys supply Saturn mass sensitivities and below, leveraging a self-referencing PSF subtraction strategy, and over 2000 individual sources have been identified for deeper investigation, with many attributable to background contaminants. Nevertheless, through PSF spatial structure, color analysis, and archival comparisons, we have obtained a sub-sample (of order tens) high-priority exoplanet candidates. While further observations to confirm common proper motion will be necessary to truly validate these candidates, we are still able to estimate preliminary statistical constraints on the sub-Jupiter exoplanet population. Our observations have also revealed several debris disk detections, further demonstrating JWST NIRCam's unique capabilities for scattered light disk imaging. Following further verification of our candidates, we aim to refine our occurrence rates, and define a robust sample of cold, low-mass exoplanets amenable for further characterization with JWST or other upcoming telescopes. These exoplanets will be the closest known analogues to our own Saturn and Jupiter, and future population-level characterization studies may lead to deeper insights into the formation and evolution of gas giants, and planetary systems as a whole.

Nulling interferometry at the VLTI with Asgard
Adam K Taras (Leiden Observatory)

Near-infrared long baseline interferometry enables direct imaging of circumstellar environments at the milliarcsecond level. The Asgard visitor instrument suite is part of a new generation of instruments at the Very Large Telescope Interferometer (VLTI), representing a collaboration of different techniques to meet a wide range of goals. This includes direct imaging of hot jupiters to discriminate between core accretion vs. gravitational instability formation models and characterising the prevalence of exozodiacal dust around the nearest sun-like stars, both relevant to the wider exoplanet community. These goals require nulling interferometry with fringe tracking below 100nm RMS and second stage adaptive optics to equalize amplitudes. This presentation focuses on NOTT- the first long-baseline nulling interferometer in the southern hemisphere, with an inner working angle of 2 milliarcseconds - as well as the K band, sensitivity optimized fringe tracker (Heimdallr) and the H band Zernike wavefront sensor (Baldr) which employ control algorithms with loop speeds up to 3kHz. Results are reported from the commissioning of phase one (out of three) in September 2025. Also, plans for the next phase (scheduled for the first half of 2026) are outlined, with the instrument to begin the first on-sky observations using NOTT in April.

Direct spectroscopy of cool exoplanets and brown dwarfs with JWST NIRSpec
Alexander Bogdan Madurowicz (Space Telescope Science Institute)

We present results using JWST/NIRSpec moderate resolution (F290LP,G395H; R∼3000) spectroscopy to characterize the cool atmospheres of 51 Eridani b and GJ 758 B. While high contrast imaging of exoplanets and brown dwarfs typically relies on coronagraphy for starlight suppression to reach the necessary sensitivity to identify planetary signals amidst overwhelming stellar noise, a recent demonstration using computational starlight subtraction and cross correlation techniques on JWST in Cycle 1 (Ruffio+2024, Hoch+2024) has shown the potential to detect and characterize exoplanets and brown dwarfs at high contrast without a coronagraph. The technique relies on spectrally resolving molecular features in the planetary atmosphere and cross-correlating the continuum-subtracted residuals of the spectroscopic data with model templates to identify planetary signals inside the noisy diffracted starlight. Our results from GO programs 3522 and 6362 reveal spectroscopic detection of 51 Eridani b (4.8 sigma in 3.4 hrs, ∼750 K, 3 M_Jup) and GJ 758 B (40.2 sigma in 3.4 hours, ∼650 K, 38 M_Jup). 51 Eridani b is the most challenging target we have recovered with this technique so far, at a separation around 0.3" and 4 micron contrast of 1.1×10^{-5}. This dataset provides the first unambiguous confirmation of disequilibrium carbon chemistry through the identification of CO molecular features. GJ 758 b is the coldest brown dwarf companion with a dynamical mass that has been spectroscopically detected with NIRSpec and enables investigations into molecules that appear at the T/Y transition seen in isolated substellar objects.

Enabling medium-contrast direct spectroscopy of exoplanets using MIRI/MRS via forward modeling.
Alexis Bidot (STScI)

MIRI/MRS is the only instrument operating in the mid-infrared range (4.9 to 27.9 um) combining medium spectral resolution (R from 3000 to 1600) and superb angular resolution. These specifications added to its extreme sensitivity make it a unique instrument for characterizing and studying various objects such as cold planets, disks, and CPDs. Although MIRI/MRS is not equipped with coronagraphs, cross-correlation methods such as molecular mapping techniques are effective for subtracting the starlight and for detecting high-contrast objects. This has been demonstrated robustly with NIRSpec/IFU or Fixed Slits achieving a contrast of up to 1.1×10^{-5} at 0.3" (Madurowicz+2025). However, observing in the mid-infrared range brings additional challenges compared to the near-infrared range. Detector effects make the calibration process particularly difficult, introducing spectral fringing and other systematic errors that interfere with the detection of these faint objects. These undesirable effects are dominant at short separations (< 3 lambda/D) (Martos 2025) limiting detections. Currently, the default JWST calibration pipeline is not optimal for reducing point source data, in particular due to fringing, and is being improved (Argyriou 2020, Gasman 2024, 2025). In order to get as close as possible to photon noise limits, we combine recent customized calibration methods for point sources (Gasman 2025) with forward modeling techniques directly in the detector space to eliminate other systematic errors due to cube reconstruction (Ruffio 2024). I will present preliminary results obtained on the HR8799 system and conclude on what can be better anticipated during the observation preparation process.

High Order Dithering on HiCAT testbed: extending JWST small grid dithering strategies on Roman CGI
Alexis Lau (LAM, Marseille)

The Roman Space Telescope Coronagraphic Instrument (Roman CGI) will be a pathfinder mission to demonstrate high-contrast imaging technologies enabling the characterisation of exoplanets in reflected light. With active wavefront control, CGI aims to achieve a contrast limit of 1e-7 or better at 3–9λ/D separation for the first time in space. In practice, temporal wavefront changes between science and reference observations set the detection floor. If the reference library doesn't span the science speckle field, post-processing either leaves speckle residuals or over-subtracts, biasing and dimming the planet signal. We investigate strategies to mitigate this mismatch by introducing high-order dithering beyond tip-tilt during reference star observations,extending the small-grid dithering approach employed on the James Webb Space Telescope. Experiments are conducted on the High-Contrast Imager for Complex Aperture Telescopes (HiCAT) testbed, where controlled aberrations are applied to evaluate their effect on achievable contrast. We present the first demonstration of this approach on a functional testbed, showing consistent performance gains across Zernike modes (Z5-Z24). Mixing linear combinations of these modes with their constituent single modes yields the most robust improvements, with repeatable gains of 1.5–3× in throughput-corrected 5σ post-processed contrast at separations of 5–8λ/D. This corresponds to 0.44–1.19 mag deeper detection limits, improving the detectability of nearby Jupiter analogues from marginal to probable. At smaller separations of 4–5λ/D, certain modes and dithering strategies provide gains of up to 2× (≈0.75 mag). Small-amplitude probes tend to under-drive the improvement, while very large probes exhibit reduced performance near the outer working angle. These results demonstrate that high-order dithering can significantly enhance reference-based post-processing, providing a pathway to improved exoplanet detection limits for Roman CGI and future missions.

Characterisation of giant planets at high spectral resolution: recent results from VLT HiRISE
Allan Denis (Laboratoire d'Astrophysique de Marseille)

A major endeavour of this decade is the direct characterization of young giant exoplanets at high spectral resolution to determine the composition of their atmosphere and infer their formation processes and evolution. Such a goal represents a major challenge owing to their small angular separation and luminosity contrast with respect to their parent stars. In recent years, several instruments have incorporated fiber coupling between adaptive optics-equipped systems and high-resolution spectrographs to enable the characterization of low-mass companions. Among them is the HiRISE visitor instrument on the VLT-UT3, which combines the SPHERE exoplanet imager with the upgraded CRIRES spectrograph to enable new science. Since its commissioning at the summer of 2023, we observed several previously imaged sub-stellar companions. In this presentation, we will focus on the cold super-Jovian companions AF Lep b and 51 Eri b. We unambiguously detect methane in the atmosphere of AF Lep b, and derive a super-solar C/O ratio, consistent with low-resolution analyses. For the first time, very high-resolution spectroscopy of these companions enables us to derive their radial and projected rotational velocities. First, the projected rotational velocity allows us to set the first constraints on the rotation periods of these objects. Combining this information with that from future photometric variability studies will enable us to determine the inclination of the rotational axis and the rotational velocity. Conversely, combining radial velocity measurements with known astrometry enables us to fully constrain their three-dimensional orbital properties. Notably, we can now derive the phase curve of such companions, which is crucial for follow-up observations in reflected light using upcoming instrumentation.

Orbital Analysis of HR8799 Using GRAVITY High Precision Astrometry
Amanda Mia Chavez (Northwestern University)

HR8799 is a young multi-planet system that uniquely hosts four gas giants. In particular, it is the only directly imaged system for which we observe more than two exoplanets, enabling a unique study of planet-planet interactions through high precision astrometry. The system has been well-monitored through imaging and spectroscopic observations for over a decade and was most recently observed with GRAVITY, an interferometric instrument on the Very Large Telescope (VLT). GRAVITY is capable of astrometry 100x more precise than previous imaging instruments (SPHERE and GPI). With measurement errors on the order of 10 micro-arcseconds, our observations produce unparalleled constraints on the orbital parameters for all four HR8799 planets. Here, I present the newest orbital constraints from GRAVITY and discuss the formation and migration history of the system. For the first time, we constrain the mutual inclination of the planets to a few degrees and present an orbital architecture that differs from the previous coplanar assumptions. I show that the consecutive planet period ratios fall just outside the exact 2:1 period ratio and discuss the implications for orbital resonances needed for dynamic stability.

Results from the JWST NIRCam and MIRI GTO Debris Disks programs
Andras Gaspar (Steward Observatory , The University of Arizona)

We report on the findings from the JWST NIRCam Scattered Light Disks (2780) and the MIRI Archetypical Disks (1193) GTO programs. These large programs ($\sim$ 50+25 h) were the first deep imaging surveys of debris disk systems with JWST, teaching us not only about the systems themselves, but also on best practices for observations and data reduction with JWST. I will provide a short review of these in my talk. The NIRCam program observed five systems (HD 10647, HD 32297, HD 61005, HD 107146, HD 181327) with the MASK335R coronagraph that were already known to host optically bright and spatially well resolved disks. The six-color dataset provides a unique opportunity to study the mineralogical composition of the disks through wavelength dependent scattering phase function (SPF) analysis as well as the dust size segregation in the systems. Placing the Solar System in context, we compare the observed SPFs to those of asteroids, comets, and TNOs in the solar system and analyze the water-ice content of the disks. The MIRI observations, on the other hand, provide the first spatially resolved images of the nearest asteroid-belt analog regions around the three closest systems where they can be observed: Vega, Fomalhaut, and epsilon Eridani. We compare the results from the three systems, revealing remarkably that all three of them host extended inner warm disks, resulting from continuous transport of dust from the outer regions. The transport mechanism for Vega and Fomalhaut, however, is not the same as for epsilon Eridani. I will review the structures we detected and the underlying dynamics and planetary system architectures we can infer from these observations.

Upgrading SPHERE with the second stage AO system SAXO+: a technology demonstrator for PCS
Anthony Boccaletti (LIRA, Paris Observatory)

SAXO+ is a second stage adaptive optics system developed by the SPHERE+ consortium which is part of the ELT/PCS roadmap. The goal is to boost the contrast performance of SPHERE at short angular separations with a series of innovative technics, both hardware and software. SAXO+ is expected to be on-sky end of 2027/beginning 2028. The detection and characterization of exoplanets and circumstellar disks constitutes the main science driver. More specifically, SAXO+ aims 1/ to provide access to the bulk of the young giant planet population down to the snow line (3–10 au), to bridge the gap with complementary techniques (radial velocity, astrometry); and 2/ to observe fainter and redder targets in the youngest (1–10 Myr) associations compared to those observed with SPHERE to directly study the formation of giant planets in their birth environment. SAXO+ works in cascade with SAXO, the 1st stage AO, and implements an IR double pyramid system coupled to a fast tip/tilt modulator, a GPU-based Real Time Computer, a 32x32 MEMS deformable mirror, and a low noise IR camera. It will achieve a maximum frequency of ∼3kHz for bright stars and will be able to observe targets as faint as J=12.5. According to simulations, SAXO+ will provide a significant improvement in contrast performance compared to SAXO for very bright stars by an order of magnitude, and also for stars redder than J=9 by one to even two orders of magnitude. As a technology demonstrator SAXO+ will mainly serve to test several flavors of AO control algorithms on-sky involving linear and non linear solutions as well as machine learning methods. We will present the science cases, the system choices, the expected contrast performances, and the schedule.

Mapping Exoplanets and Brown Dwarfs across Space and Time
Arthur Daniel Adams (University of Virginia)

We report on recent results of three projects that span a range of exoplanet characterization approaches with JWST data. First we discuss the observatory's first time-resolved spectra of a planetary-mass companion (in the 2M1207 system) with the NIRSpec IFU. 2M1207 A (T∼2500 K, M∼25 Jupiter masses) shows a combination of periodic and non-periodic structures that may be attributed to starspots and other temperature variations, as well as potential signatures of ongoing accretion. The time series of 2M1207 b (T∼1200 K, M∼5 Jupiter masses) shows broad agreement with existing models of the time variability that invokes cloud inhomogeneity. The second project covers an update to the atmospheric characterization of the intriguing widely-separated exoplanet HD 106906 b with JWST NIRSpec data. Previous studies provide evidence that we are viewing the planet close to pole-on; we place our findings in context of theories of giant planet circulation that predict that, similar to the solar system giants, the polar regions may exhibit vortices that are dynamically and spectrally distinct from lower latitudes. Our third study introduces the mapping in eclipse of brown dwarf companions around white dwarf hosts, a new frontier for the spatially resolved characterization of sub-stellar objects.

The Roman Coronagraph and Its applicability to HWO
Bertrand Mennesson (NASA JPL)

The Nancy Grace Roman Space Telescope will nominally be launched within a year. It includes an onboard Coronagraph Instrument (CI) which will serve as a technology demonstrator for high contrast spectro-imaging and polarimetry at visible wavelengths. The Roman CI will be capable of detecting and characterizing exoplanets and circumstellar disks in visible light at an unprecedented contrast level of ∼10-8 or better at small separations. In particular, the Roman CI will be the first space-based coronagraphic instrument with active low- and high-order wavefront control through the use of two large format (48x48) deformable mirrors, and its electron-multiplying Charge Coupled Device (EMCCD) detector will enable faint signal detection in photon-counting mode. The Roman CI is now well on its path to demonstrate many core technologies at the levels required for a future exo-Earth direct imaging mission like the Habitable Worlds Observatory (HWO).

GPU-Enabled Debris Disk Modeling with GRaTeR-JAX
Briley Lynn Lewis (UCSB)

Past efforts in disk modeling have been somewhat limited in their ability to explore disk parameters due to intractably large computation times; accordingly, disk models often include assumptions for a number of model parameters. The newly presented GRaTeR-JAX package–a JAX-based implementation of the Generalized Radiative Transporter framework for circumstellar disk image modeling originally introduced in Augereau+ 1999–is able to fit tens of parameters with both least-squares minimization and Markov Chain Monte Carlo in hours, thanks to improvements in speed from GPU computation and automatic differentiation. This enables us to explore parameters that are generally fixed via assumptions–such as the flaring coefficient and eccentricity–and to fit for a disk's scattering phase function (SPF) with a spline, eschewing the traditional Henyey-Greenstein function in favor of a more flexible framework. This work presents a uniform analysis of H-band polarimetric data from the Gemini Planet Imager using GRaTeR-JAX, revealing population-level trends in disk morphology and SPF, with implications about the disk's dust composition.

The Gemini Planet Imager and the Road to GPI 2
Bruce Macintosh (University of California Observatories)

The Gemini Planet Imager (GPI) was one of the first dedicated high-contrast "extreme AO" instruments on a 8 to 10m telescope. Designed from the beginning with a science-driven process as a facility instrument, it incorporated many now-standard features including high-order AO (1800 actuators), integral field spectroscopy, apodized-pupil coronagraphs, high-accuracy wavefront control, and a fully functional data pipeline. GPI was operational on the Gemini South telescope from 2013-2019 and carried out the large GeminI Planet Imager Exoplanet Survey of nearby young stars as well as a variety of individual PI science programs. I will highlight lessons learned from GPI on both the instrumentation and science impact. These lessons have been used to drive the GPI2 upgrade. Incorporating a pyramid wavefront sensor, high-speed realtime computer, new coronagraph designs, and other upgrades, GPI2 will be deployed on the Gemini North telescope in the second half of 2026; I will review its status and expectations.

For a Few Photons More: Design and Development Updates for HWO Testbeds at JPL
Caleb W Baker (Jet Propulsion Laboratory)

As the Habitable Worlds Observatory architecture, systems, and modelling teams work through a new set of exploratory analytical architectures, its hardware and technology teams remain focused on TRL5 testbed demonstrations of critical observatory technologies. At the Jet Propulsion Laboratory, work continues on our TRL-5 coronagraphic testbeds, with optical alignment of our static high contrast demonstration testbed now underway. In this talk, we will provide updates on our testbed design, hardware progress, and strategy for demonstrating HWO coronagraphy architectures – along with a refresher on our testbed optical design and plans for community involvement and data access.

SpeckleNet: a generative deep learning framework for speckle modeling
Carles Cantero (Observatoire de Geneve)

In High Contrast Imaging (HCI), Principal Component Analysis (PCA; Soummer et al. 2012; Amara et al. 2012), and some of its modifications (i.e., Absil et al. 2013), have been the standard approach to model speckle noise in differential imaging strategies for the last decade. Its popularity stems from its efficiency, availability, and single tuning parameter: the number of principal components K. However, in recent years, several studies have highlighted key drawbacks that limit detection sensitivity: PCA is restricted to linear correlations, suffers from planet self-subtraction, and requires a non-trivial choice of K (Bonse et al. 2025). To address these issues, alternative approaches have been proposed, including improvements to PCA and the use of machine learning classifiers to enhance detection (e.g., Cantero et al. 2023). More recently, advances in the field of generative models have shown particular promise. For example, the ConStruct algorithm (Wolf et al. 2024) replaces PCA with a convolutional autoencoder (AE) achieving deeper detection limits than annular PCA on Keck/NIRC2 data and providing a strong proof-of-concept for this technology. In this context, the growing availability of large-scale HCI datasets from surveys, the rapid progress in generative model architectures, and the improved understanding of speckle noise gained in recent years now converge to enable more powerful approaches for speckle subtraction and substellar direct imaging. To harness this potential, we introduce SpeckleNet, a deep learning framework for high-fidelity, instrument-based speckle modeling. SpeckleNet explores modern generative architectures, including variational autoencoders, diffusion models, and others, trained on extensive HCI datasets to capture both spatial and temporal correlations in speckle noise. The framework also employs conditional learning, allowing adaptation to atmospheric conditions. In this work, we present the first SpeckleNet release, demonstrating its potential to push HCI detection limits and its flexibility to adapt to upcoming instrument upgrades such as VLT/SPHERE+.

SPIDERS Habitable Worlds Observatory Experiment: Can we Reach 10^{10} Contrast (from $\sim 10^7$) with CDI and R10,000 SDI Post-Processing?
Christian Marois (National Research Council of Canada)

I will present ongoing high-contrast imaging research using the National Research Council of Canada SPIDERS pathfinder to use the coherent differential imaging (CDI) and spectral differential imaging (SDI) post-processing techniques with an in-air 10^7 bench and high SNR data cubes to reach Habitable Worlds Observatory (HWO) 10^{10} contrast level. SPIDERS is a near-infrared focal plane adaptive optics system equipped with an ALPAO deformable mirror, a FAST APLC focal plane coronographic mask, a self-coherent camera (SCC), an imaging Fourier Transform Spectrograph (iFTS), a SAPHIRA-based camera, and nm RMS optics. SPIDERS is designed as a second-stage system for the Subaru AO3K system, and it is currently reaching 10^7 raw contrast using its high speed 200Hz focal plane wavefront sensor SCC loop. We recently acquired very high SNR R10,000 data cubes with the instrument iFTS to estimate the instrument's ability to reach 10^{10} contrast after post-processing. I will present our various findings on how CDI and SDI are behaving at extreme contrast, including the impact of chromatic fringing, and discuss possible paths forward to further improve broadband performances of future high-contrast imaging instruments.

Witnessing the Formation and Evolution of Planetary Systems
Christine H Chen (STScI)

Observations of protoplanetary and debris disks provide unique insight into the environments in which planetary systems form and evolve. Protoplanetary disks are disks of gas and dust around pre-main sequence stars that contain the ingredients needed to form planetary systems. Debris disks are planetary systems containing planets, planetesimals, and dust. While the circumstellar material in protoplanetary disks is left over from star formation that around debris disks is created by collisions among the planets, planetary embryos, and planetesimals. Both protoplanetary and debris disks produce observable gas and dust features that act as tracers for a host of processes within the disks. During the past decade, ground-based high contrast imaging instruments have begun to discover giant planets in both protoplanetary and debris disks. During the past few years, JWST has begun to revolutionize our understanding of the volatile ices via near-infrared scattered light and absorption spectroscopy and disk gas, winds, outflows, and jets via mid-infrared thermal emission spectroscopy and CO fundamental emission. In 2026, NASA is expected to launch the Roman Space Telescope. It's Coronagraphic Instrument (CGI) promises to enable detailed characterization of dust in the habitable zone. I will review the current state of protoplanetary and debris disk observations and foreshadow advances expected from Roman.

PICTURE-D First Flight Results
Christopher Mendillo (UMass Lowell)

The Planetary Imaging Coronagraph Testbed Using a Recoverable Experiment for Debris Disks (PICTURE-D) is a NASA high-altitude balloon mission to directly image exoplanetary systems with the goal of characterizing the inner debris disks of several nearby stars in reflected visible light. The observatory performed its first balloon flight on October 1, 2025 from the NASA CSBF launch facility in Ft. Sumner, NM. The experiment consists of a 60 cm off-axis telescope coupled with a coronagraph instrument containing high and low-order wavefront control systems, dual BMC MEMS deformable mirrors and a charge 6 vector vortex focal plane mask. During the 20 hour flight, 4 stars were observed: Vega, Altair, Fomalhaut and the Gamma Cassiopeiae binary system. On-sky contrast was limited to the 1e-6 level due to poor EFC dark hole convergence and residual pointing jitter owing to a throughput issue with one of the low-order wavefront sensors. We present the observational results from the flight and a description of the technical performance of the observatory sub-systems.

The Habitable Worlds Observatory and the Search for Other Earths
Christopher Stark (NASA GSFC)

The Habitable Worlds Observatory (HWO) is NASA's future flagship space telescope and the top recommendation of the Astro2020 Decadal. This mission seeks to directly image and characterize Earth-like planets around other stars to search for signs of life. What will this ambitious goal require in terms of high contrast imaging and how do we achieve it? In this talk, I will put the scientific goals and challenges of HWO in the context of Webb and Roman. I will review the performance improvements required, how observations must be conducted, and the targets we expect to observe. I will discuss the path forward to achieving these goals and summarize progress made to date by HWO's Technology Maturation Project Office and the larger astronomical community.

Accretion and Circumplanetary Disk Properties of a Wide Orbit Planet with HST and JWST
Claire Finley (The University of Texas at Austin)

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 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. In the mid-IR, we detect substantial thermal excess from a circumplanetary disk and search for signs of grain growth. This snapshot of active accretion onto 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.

Imaging cold exoplanets with JWST: a case study of Eps Ind Ab
Elisabeth Matthews (MPIA)

I will present the first direct image of a solar-age exoplanet: the nearby gas giant Eps Ind Ab. At $\sim$275K and $\sim$4Gyr, this planet highlights the opportunity to image cold, old planets around some of our closest neighbors with JWST. Eps Ind Ab is confirmed as a planet with three epochs of common proper motion, while photometry between 10-15micron indicates that it is more luminous than thermal evolution models predict and has a clear ammonia absorption feature. However, the ammonia abundance is lower than atmosphere models predict, and the planet was not detected in archival observations between 3-5micron. These two constraints together strongly suggest an atmosphere containing thick water-ice clouds. While the presence of Eps Ind Ab was predicted based on radial velocity (RV) and astrometric observations, JWST imaging revealed it to be significantly more massive and further from its star than predictions. I will present our ongoing campaign to monitor the system with RV measurements, and to understand the root cause of this mismatch:

is it due to biases in the RV analysis, overly restrictive priors in published analyses, or perhaps even additional bodies in the system? Determining the cause of this mismatch will be crucial as we consider observing plans for more RV planets, with JWST and also future facilities such as Roman and ELT/METIS. Alongside our coronagraphy of Eps Ind Ab, I will also present spectroscopic JWST observations of Eps Ind BA/BB: the brown dwarf binary that is co-moving with Eps Ind Ab, and presumably shares an age and formation location with the giant planet. This unique system thus provides an ideal lab to study planet and brown dwarf formation, to compare luminosity as a function of mass in a co-eval system, and interpret composition and isotope abundances measured in the Eps Ind Ab atmosphere.

Comprehensively characterizing companions through a multi-measurement approach
Emily Rickman (STScI)

As the number of exoplanet and brown dwarf companions has increased in recent years, the mass-separation parameter space of detection techniques from the observational biases that are inherent to each is evident. With advancements in instrument technology and telescopes with greater angular resolution and sensitivity, paired with new sophisticated data processing techniques, we have reached an era where the gaps between techniques is starting to be bridged. The radial velocity method gives rise to fundamental orbital parameters, and when combined with astrometry from Hipparcos and Gaia, the degeneracies in unknown orbital parameters are removed revealing the true dynamical masses of unseen companions. This wealth of data, including the upcoming Gaia DR4, provides crucial information for high-contrast observations that historically have suffered from low yields from blind surveys. The impact has been twofold. Not only has this led to an increase in detection efficiency of directly imaged companions, but allows comprehensive characterization of those that are detected. In addition to refined dynamical masses from imaging measurements, direct spectroscopic measurements can reveal hidden clues into complex atmospheres, sharing hints of possible formation mechanisms and dynamical histories. In this talk, I will review the current status of combining detection techniques in the context of high-contrast observations, the power in doing so, and what we have learned so far.

The Commissioning Plan for the Roman Space Telescope Coronagraph Instrument
Eric Cady (NASA/JPL)

The Coronagraph Instrument for the Roman Space Telescope is a technology demonstration instrument for coronagraphic high-contrast imaging with active wavefront control on a space telescope, working at contrasts capable of reflected-light imaging of exoplanets. Roman is on track for launch in fall 2026, and after launch will immediately begin in-orbit commissioning activities across the entire observatory. We describe the commissioning approach at both Roman and instruments, commissioning exit criteria, and planned scope of work, including activities beyond the baseline to be run if there is sufficient time.

A carbon-rich disk surrounding a planetary-mass companion
Gabriele Cugno (University of Zurich)

During the final assembly of gas giant planets, circumplanetary disks (CPDs) of gas and dust form due to the conservation of angular momentum, providing material to be accreted onto the planet and the ingredients for moons. The composition of these disks has remained elusive, as their faint nature and short separations from their host stars have limited our ability to access them. Applying well-known post-processing techniques to JWST/MIRI Medium-Resolution Spectrograph (MRS), we can now observe and characterize this reservoir for wide-orbit planetary-mass companions for the first time. In this talk, we will present the first molecular spectrum of a disk surrounding a planetary-mass companion at medium resolution in the 12-16 micron range. The spectrum of CT Cha b reveals the elemental composition of the disk, which can be compared to that of the atmosphere of the companion to constrain its accretion history. Furthermore, strong differences between the chemistry observed in the disk around the companion and the disk surrounding the star indicate rapid, divergent chemical evolution on million-year timescales. These results set the stage for a broader survey that will be conducted during JWST Cycle 4, in which we will observe all CPDs accessible by MIRI MRS to study their gas and dust composition and physical properties. We will conclude by highlighting some preliminary results from these programs.

Dual-purpose Focal Plane Masks for Simultaneous Wavefront Sensing and High-contrast Imaging
J. Kent Wallace (Jet Propulsion Laboratory)

Direct detection of earth-like planets in the visible portion of the spectrum using a space-based telescope with an internal coronagraph will require a system that can achieve a 10 billion to 1 raw contrast which must be maintained for the duration of the science observation lasting up to 10s of hours. In turn, this requires a telescope wavefront stability on the order of $\sim$ 10 picometers over a time scale of $\sim$ 10 minutes. Passive wavefront stability of a space telescope at this level has never been demonstrated, and architecting such a passively stable system must be weighed against the alternative method of active sensing and control. While sensing and control may seem to complicate the system architecture, it also enables performance and modalities that are otherwise not feasible. However, the sensing must be done during the science observation, and with a minimum of non-common path errors. The sensing and control must be done where it matters most – at the location of the focal plane mask. We have architected and implemented such a device, that enables both of these capabilities. In this talk we will first discuss the key design elements of the optical element, and second we will discuss how it has been used in the lab to:1) experimentally demonstrate broadband contrasts at the 10-10, 2) achieve sub-picometer wavefront sensing of Zernike modes, Fourier modes, and individual actuator pokes, 3) active, dynamic stabilization of the high-contrast state using the wavefront sensing.

Reinforcement learning for wavefront control: from WFS control to focal plane and from numerical simulations to lab and on-sky with PAPYRUS @ OHP
Jalo Aarni Johannes Nousiainen (European Southern Observatory)

Highest-contrast imaging with ELT-PCS requires a highly performant and robust control system. The main science case of nearby Exo-Earths calls for high contrast at very small angular separations of tens of milliarcseconds, where the contrast is affected by quickly changing eXtreme AO residuals and quasi-static speckles. Reinforcement Learning (RL), a subfield of machine learning where system control is learned through interaction with the environment, holds great promise and is now receiving much interest in the XAO field. In particular, model-based RL methods are shown to mitigate temporal and misregistration errors, as well as adapt to moderately non-linear wavefront sensing. Future challenges for these approaches include on-sky testing, adaptation to highly non-linear WF-sensing, and focal plane wavefront control to tackle the quasi-static speckles. In this work, we discuss our latest advances on all of these aspects. First, we discuss mode-based RL methods applied to focal plane wavefront control, utilizing sequential phase diversity. We demonstrate how this method can be applied to dynamic and static NCPA errors, without any prior knowledge of the optical system. Second, we discuss the results of our first on-sky tests on PAPYRUS at OHP, and we introduce a novel RL algorithm that combines reconstruction and temporal control steps into a full end-to-end RL model, thereby improving the effective dynamic range of the Zernike wavefront sensor on the GHOST test bench.

Jupiter Analogs in Sight: Modeling the Coldest Directly-Imaged Atmospheres Observed with JWST
James Mang (UT Austin)

JWST is transforming our view of the coldest worlds, from ultra-cool brown dwarfs to directly imaged giant planets. Early JWST programs observing benchmark systems such as Eps Indi Ab, 14 Her c, and WISE 0855 have paved the way for additional JWST programs and surveys that aim to detect and characterize even smaller, colder objects, bringing us closer to true Jupiter analogs. These systems provide the best opportunities to test atmospheric models of cold substellar objects and to incorporate new treatments of atmospheric dynamics and chemistry. To address this challenge, we have developed the next generation of Sonora atmospheric and evolutionary models: Sonora Flame Skimmer. This new grid extends to colder temperatures and includes disequilibrium chemistry across a wide range of metallicities and C/O ratios. Applying them to JWST observations of Eps Indi Ab, 14 Her c, WISE 0855, and other new discoveries, we demonstrate both the successes of current models and the areas where tensions remain. A key lesson from JWST so far is that single-band photometry, particularly at 4 μm, can be misleading without a broader spectral context. In this talk, I will discuss our use of Sonora Flame Skimmer and custom PICASO models to characterize benchmark systems, outline best practices for interpreting cold substellar atmospheres with JWST data, and highlight the critical roles of multi-band coverage, clouds, and chemistry in their characterization. Together, these advances lay the groundwork for more reliable atmospheric modeling and for optimizing future JWST and Roman observing strategies.

GMagAO-X: High-Contrast Imaging at First-Light of GMT

Jared Males (Steward Observatory, University of Arizona)

GMagAO-X will be the first high-contrast imager on the Giant Magellan Telescope, and has now been added to the GMT project baseline plan. This instrument will realize the revolutionary increase in spatial resolution and sensitivity provided by the 25 m GMT. GMagAO-X is in the final design phase and is on track to be ready at first-light in the mid 2030s. It will enable, for the first time, the spectroscopic characterization of nearby potentially habitable terrestrial exoplanets orbiting late-type stars. Additional science cases include: reflected light characterization of mature giant planets; measurement of young extrasolar giant planet variability; characterization of circumstellar disks at unprecedented spatial resolution; characterization of benchmark stellar atmospheres at high spectral resolution; and mapping of resolved objects such as giant stars and asteroids. These, and many more, science cases will be enabled by a 21,000 actuator extreme adaptive optics system, an integrated coronagraphic wavefront control system, and a suite of imagers and spectrographs. Science-driven performance requirements for GMagAO-X include achieving a Strehl ratio of 70% at 800 nm on 8th mag and brighter stars, and characterization at flux-ratios of 1e-7 at 4 lambda/D (26 mas at 800 nm) separation. We will provide an overview of the instrument design to achieve these ambitious performance targets and the resultant expectant scientific yield.

Lessons Learned on Combining High-Contrast Imaging with High-Resolution Spectroscopy after 7 years of KPIC

Jason Wang (Northwestern University)

Feeding the light from a high-contrast imaging system to a high-resolution spectrograph (HCI+HRS) enables us to use the combination of spatial and spectral information for starlight suppression. The HCI+HRS technique shows great promise and is considered for future observatories to enable the study of terrestrial planet atmospheres. The Keck Planet Imager and Characterizer (KPIC) was the first instrument to demonstrate the HCI+HRS technique on sky and has obtained spectra of more than 30 directly imaged companions since 2019. With KPIC scheduled for decommissioning at the end of 2025B, I will summarize the lessons learned from 7 years of on-sky operations of KPIC. On the hardware side, I will discuss the relative ease of using single mode fibers and unanticipated HCI+HRS systematics that limit KPIC planet sensitivity such as spectral fringing from dichroics. Regarding instrument performance. I will discuss the relative importance of end-to-end throughput compared to raw contrast for HCI+HRS and its ability to nearly reach the fundamental photon noise floor. For the science return of HCI+HRS, I will discuss the unique measurements enabled by high resolution, such as making robust atmospheric abundance measurements by finding wavelength ranges where high-resolution spectra are relatively insensitive to clouds. I will summarize how these findings from KPIC can be used to optimize the performance of future HCI+HRS instruments planned at current and future observatories.

Data analysis techniques in high-contrast imaging

Jean-Baptiste Ruffio (UC San Diego)

High-contrast imaging is currently sensitive to closely separated planets (<1") that are $\sim 10^{-7}$ fainter than their stars. As a field, we are therefore about halfway between the detection of the first directly-imaged exoplanets (10^{-4}) and our goal to search for biosignatures in the atmospheres of Earth analogs with a flux ratio of 10^{-10}. Progress has not only been driven by major advances in

instrumentation, but also by the development of increasingly sophisticated data-analysis techniques designed to disentangle planets from variable starlight (a.k.a., speckles). I will discuss the key principles and challenges of high-contrast data processing techniques, their evolution, and possible paths forward to acquire the first exoEarth spectra by the 2040s.

Metal enrichment in both volatile (C, O, N) and refractory (S) elements for giant planets in HR 8799 and AF Lep
Jerry Xuan (UCLA)

The accretion of solids during the formation of a gas giant planet is poorly constrained and challenging to model. Refractory species, like sulfur, are only present in disk solids at the orbital distances of directly imaged planets, and provide the most direct way of constraining the extent of solid accretion. I will present JWST/NIRSpec high-contrast observations of the four HR 8799 planets from 2.85-5.3 um (R$\sim$2700), which provide unambiguous detections of CO, CH4, H2O, H2S, CO2, and for planet b, NH3. From atmospheric retrievals, we find all four planets are enriched in carbon and oxygen at the 3-5x stellar level, and sulfur at the 2-5x stellar level. The sulfur enrichment explicitly demonstrates that these planets accreted significant amounts of solids. The S/H values decrease with decreasing orbit distance, indicating the total solid mass accreted by each planet decreases closer in. From the volatile and refractory abundances, planet b is consistent with formation between the CO and N2 snowlines, while the inner planets likely accreted CO-enriched gas inside the CO snowline. I also present JWST/NIRSpec observations of AF Lep b, which achieve a ¿50 sigma detection of the planet at 0.29 arcsec. Our preliminary analysis indicates AF Lep b is nearly uniformly enriched in C, O, and S, similar to HR 8799 b and our own Jupiter. I place these findings in the broader context of abundances for directly imaged companions, and highlight an emerging compositional divide where planets tend to be metal-enriched, while brown dwarf companions have compositions consistent with their host stars.

Finding the great sculptors: A Renaissance in Planet Disk Dynamics
Jingwen Zhang (University of California, Santa Barbara)

Understanding how planetary systems form and evolve is a central goal of modern exoplanet science. In our Solar System, Neptune sculpts the Kuiper Belt through resonances, but similar signatures are much harder to discern in extrasolar systems, where long-period giant planets and debris disks are seldom observed together. I will present results from a JWST/NIRCam survey of 13 systems chosen for their sensitivity to giant planets. A key highlight is CPD-72 2713, a 24 Myr-old member of the beta Pic moving group, where we obtained the first scattered-light images of its nearly face-on debris disk in the F210M and F444W filters. We also identify a planet candidate at $\sim$120 AU, with photometry consistent with a Saturn-mass companion. If confirmed, this system would offer a rare and compelling case study of planet–disk interactions in a young planetary system. Finally, I will present results from the full sample, which constrain planet occurrence rates down to below one Jupiter mass, enabling the first demographic study of such 'sculptor planets'.

Tracing Shadow Variability in Protoplanetary Disks with Multi-Epoch Scattered-Light Imaging
Jinlin Li (Kavli Institute for Astronomy and Astrophysics, Peking University)

Planets form in protoplanetary disks, which are gaseous and dusty disks surrounding newborn stars. We use VLT/SPHERE to carry out multi-epoch NIR scattered-light imaging observations of 40 protoplanetary disks over a decade. Some of the targets, such as SAO 206462 and HD 163296, have up to six epochs of observations. The sample reveals that shadows are common in protoplanetary disks, and they vary on timescales from days to years. By applying a variety of analysis methods and radiative transfer simulations, we characterize the morphology and evolution of shadows, and explore their possible origins. We also investigate the connection between shadow variability and various stellar and disk properties.Furthermore, we use shadow variability as a unique probe of physical processes in the otherwise unresolved inner disks on AU scales. These processes include precession of the inner disk driven by magnetic fields, companions, or infall, as well as puffing-up of the inner rim caused by temperature variations. Our results demonstrate that the inner disk region is not a simple axisymmetric structure, but instead hosts diverse non-axisymmetric features. We discuss the key implications of this study for the formation of terrestrial planets in inner disks.

Exoplanet Atmosphere Models: Strengths, Weaknesses, and the Future
Jonathan Fortney (UC Santa Cruz)

Our understanding of exoplanet and brown dwarf atmospheres is currently being dramatically revised from spectra from JWST and high-resolution instruments on ground-based telescopes. I will highlight the role of 1D and 3D models in comparing to high-quality observations to better understand cool atmospheres. I will discuss the various flavors of models and the trouble-spots that the field is currently trying to address. For future observational capabilities a hierarchy of models, from simple to sophisticated, will be important for making future progress.

Two Populations, Two Histories: Orbital Eccentricities of Exoplanets and Brown Dwarfs
Jonathan Roberts (Northwestern University)

Our work explores the orbital architectures of substellar companions found at wide separations (3–420 AU) using a population-level analysis of 61 directly imaged companions, including 23 exoplanets and 38 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.

Lab Demonstration of the Spatially-Clipped Self-Coherent Camera
Joshua Liberman (University of Arizona)

The Habitable Worlds Observatory requires active speckle suppression to directly image Earth-like exoplanets. Focal plane wavefront sensing and control allows us to detect, and subsequently remove, time-varying speckles through measurements of the electric field. Two measurement-based wavefront sensing approaches are pairwise probing and the self-coherent camera (SCC). However, the pairwise probing technique is time-consuming, requiring at least 4 images and reducing the speed at which aberrations can be eliminated. In the classical SCC, a coronagraph mask diffracts light outside of the Lyot stop where it is filtered with a pinhole. The filtered light creates a reference beam, interfering with speckles that leak through the coronagraph. The classic design of the SCC only works over small spectral bandwidths and requires significantly oversized optics which limits its effectiveness. We implement a new SCC variant, the Spatially-Clipped Self-Coherent Camera (SCSCC). The SCSCC utilizes a pinhole placed closer to the Lyot Stop, reducing the overall beam footprint and boosting the sensor's spectral bandwidth. A knife-edge beam splitter downstream of the Lyot Stop splits the light into 2 channels: fringed and unfringed. This allows us to sense the wavefront with a single exposure. Time-varying aberrations are effectively frozen in place, making them easy to remove. To run our sensing and control loop at high speeds of $\sim$100 Hz, we pair our SCSCC with the Hamamatsu Orca-Quest 2 quantitative CMOS (qCMOS) detector–capable of achieving sub-electron read noise. We present the opto-mechanical model of the SCSCC along with design trade-offs, such that our sensor can be adapted for use on numerous telescopes. Furthermore, we characterize the properties of our qCMOS detector and demonstrate lab results of the SCSCC in a sensing and control loop. Our results make the SCSCC a valuable wavefront sensor for upcoming missions, including the Giant Segmented Mirror Telescopes and the Habitable Worlds Observatory.

SCExAO's evolution toward multi-stage AO correction & astrophotonics

Julien Lozi (Subaru telescope)

The Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) system, fed by its upstream 3000-actuator "woofer" (AO3k), serves both as a platform for high contrast imaging (HCI) technology maturation and as a science instrument for imaging, spectroscopy, and polarimetry of exoplanets and disks. SCExAO operates in the visible and near-IR and offers a wide choice of instrument configurations. Over the last year, AO3k/SCExAO underwent significant upgrades to bring improved capabilities and support new developments, all while easing science operations. The new configuration features a beam switcher so that light can be shared between several instrument modules, including the upcoming NINJA near-IR spectrograph and the SPIDERS HCI pathfinder. The system is evolving toward a tighter integration between multiple WFSs and AO stages of correction, with the first stage (AO3k) providing visible and near-IR WFSing, as well as laser tomography. The system is also increasingly integrating emerging photonic technologies (optical fibers and optical photonic circuits) for improved wavefront sensing, starlight suppression and high accuracy science measurements. These changes are aligned with several overlapping emerging axes of research in HCI systems: (incl. high performance wavefront control, astrophotonics, and PSF calibration) that are driving the design of future systems for large ground and space telescopes.

CorGI-REx, the bright reference star vetting campaign for the Roman Coronagraph and beyond
Justin Hom (University of Arizona)

The upcoming Roman Coronagraph will be the first high-contrast instrument in space capable of high-order wavefront sensing and control technologies, a critical technology demonstration for the proposed Habitable Worlds Observatory (HWO) that aims to directly image and characterize habitable exoEarths. The nominal Roman Coronagraph observing plan involves alternating observations of a science target and a bright, nearby reference star. High contrast is achieved using wavefront sensing and control, also known as "digging a dark hole", where performance depends on the properties of the reference star, requiring reference star V¡3, resolved stellar diameter ¡2 mas, and no stellar multiplicity. The imposed brightness and diameter criteria limit the sample of reference star candidates to high-mass main sequence and post-main sequence objects, where multiplicity rates are high. In this work, we provide an overview of reference star criteria and the current list of reference star candidates. We describe the CoronaGraph Instrument Reference stars for Exoplanets program (CorGI-REx), a 300-hour observing campaign that utilizes instruments from around the world to vet reference stars for high-order wavefront control suitability. We will summarize the results of our initial moderate contrast survey and the latest results from high-contrast and interferometric facilities, including candidates that have been eliminated from reference star consideration due to a heightened risk of degraded contrast performance. We describe the implications of reference star criteria and properties on mission scheduling and instrument performance. Finally, we emphasize the importance of precursor vetting of these candidates to maximize Roman Coronagraph and HWO mission efficiency and return.

Machine Learning & Coherent Differential Imaging with SPIDERS
Kaitlyn Hessel (University of Victoria)

Coherent Differential Imaging is a high-contrast imaging post-processing technique that uses the coherence of stellar light to reconstruct the speckle field and isolate faint planetary signals. This method has theoretically infinite contrast however practical challenges with point spread function reconstruction and chromaticity has limited contrast gains to values ranging from 2-20x using varying methods including pair-wise probing and the Self Coherent Camera. My work aims to extend this contrast limit up to ∼30x using the Self Coherent Camera, a step that will enhance the detectability of low-mass, small separation exoplanets. It will also prepare CDI for public release to the astronomy community as part of the CAL2 system for the Gemini Planet Imager 2 on the Gemini North Telescope, an important step toward CDI deployment on NASA's Habitable World's Observatory. To date, the Self Coherent Camera CDI technique has only been tested via simulations and lab testbeds, with my work focusing on the creation of a CDI pipeline and further testing with Machine Learning. This method will undergo on-sky testing on the Subaru Pathfinder Instrument for Detecting Exoplanets and Retrieving Spectra (SPIDERS) in December 2025. This work will show the first on-sky results of CDI using a Self-Coherent Camera along with my progress using Machine Learning to reconstruct the stellar speckle field.

Searching for exo-satellites and brown dwarf binaries using the Keck Planet Imager and Characterizer (KPIC)
Katelyn Horstman (Caltech)

The Keck Planet Imager and Characterizer (KPIC) is a high contrast imaging suite that feeds a high resolution spectrograph (1.9-2.5 microns, R∼35,000) at the W.M. Keck Observatory. One target accessible with KPIC is GQ Lup B, a substellar companion with a detected circumplanetary disk, or CPD. Observations of the CPD suggest the presence of a cavity, possibly formed by an exo-satellite. Using high resolution, K-band spectra from KPIC, this study reports the first dedicated exomoon radial velocity searches around the directly imaged substellar companion GQ Lup B. Over 10 epochs, we find a median RV error of 1 km/s, most likely limited by systematic fringing, or oscillations in the spectrum's continuum as a function of wavelength due to transmissive optics in KPIC. With this RV precision, KPIC is sensitive to exomoons 2.8% the mass of GQ Lup B at a separation of 65 Jupiter radii, or the extent of the cavity measured in the CPD detected around GQ Lup B. Given previous KPIC companion sensitivities, the analysis of an additional survey focused on identifying spectroscopic brown dwarf binaries within 1 AU of their host stars is underway. By measuring companion RVs of 11 targets at least once a year for three years, this survey aims to better understand the occurrence rate and separation of these binaries as a function of mass ratio and distance to the host star. I present preliminary radial velocities for several targets between 2020 to 2025, leveraging previous KPIC observations.

Direct imaging and spectroscopy of the Beta Pictoris disk structure with JWST/MIRI
Katie Crotts (Space Telescope Science Institute)

Cycle 1 JWST/MIRI coronagraphy revealed the presence of an unexpected "cat's tail" feature extending sharply off of the SW side of the main disk of Beta Pictoris, which is additionally surrounded by complex mid-IR structure. This phenomenon, along with an observed secondary disk, may be explained by a recent collision blowing out porous organic dust particles at high speed. This model predicts a carbonaceous porous composition, and a certain trajectory compatible with the tail moving enough in two years to be detectable. New Cycle 3 MIRI direct imaging and spectroscopic observations allow us to test this prediction. Direct imaging observations reveal even more unexpected nebulosity visible only in deep observations at ¿15 microns, showing a wildly complex landscape of arcs, spirals, and tendrils extending away from the disk and tail. Additionally the NE side of the disk extends asymmetrically out to 1000 au, with a wavy and curved appearance. JWST/MRS data also allow us to probe the composition of the "cat's tail" and main disk via spatially resolved spectroscopy, which will also enable the testing of the current collisional hypothesis. All newly-seen structures appear to share a similar color to the cat's tail, bluer than the main disk, and perhaps also share a similar composition and production mechanism. The unexpectedly complex apparent debris field around Beta Pictoris poses both substantial challenges and opportunities for assessing collisional models in the aftermath of giant impacts.

Astrometric Accelerations as Dynamical Beacons: Efficiently Imaging Planets Around Young Accelerating Stars
Kyle Franson (University of California, Santa Cruz)

Directly imaged exoplanets are key tools for studying the formation, evolution, and atmospheric physics of long-period gas giants. Imaged planets with dynamical mass measurements are especially valuable, as they facilitate robust tests of cooling models. However, only about 30 exoplanets have been imaged, with only five that have direct mass measurements. In this talk, I will share the final results of the Astrometric Accelerations as Dynamical Beacons survey, a multi-facility campaign to use astrometric accelerations between Hipparcos and Gaia to increase the efficiency of imaging new long-period planets. This survey has delivered exciting discoveries including AF Lep b, the lowest-mass imaged exoplanet with a dynamical mass. Here, I will highlight the full range of data products from this campaign, which includes about two dozen high-contrast imaging sequences, over

2000 shorter imaging sequences to remove visual binaries from our sample, and numerous candidate or confirmed companions. Our survey has significantly improved the efficiency of imaging new exoplanets and serves as a prototype for systematically following up the best new informed targets that will be revealed by Gaia DR4.

A Review of Accreting Exoplanet (Protoplanet) High-Contrast H-alpha Direct Imaging Science with Magellan/MagAO-X and a Look to the Future with GMT/GMagAO-X

Laird Close (Steward Obs. University of Arizona)

Here we will review the results of our multi-year program's direct imaging at H-alpha (656.3 nm) of the young (∼5 Myr old) accreting protoplanets PDS 70 b, PDS 70 c, 2MJ1612 b and WISPIT 2b with visible ExAO (Close et al. 2025a; Li et al. 2025; Close et al. 2025b; respectively) and the MaxProtoPlanetS survey in general. These are very high-contrast (10^{-4} to 10^{-5}) observations of these planets with separations of 100-300 mas in the visible at H-alpha with the 6.5m Magellan Telescope and the 2040 actuator MagAO-X visible ExAO system. From this, admittedly small, sample of observed protoplanets (¿50% were just discovered in 2025) we can now start to see some general trends newly emerge –which are exciting to explore in this talk. We will review what we have recently learned about the spread of planet masses, accretion rates, H-alpha line fluxes/variability, and protoplanet inclinations. We will also detail some very interesting new models of these accreting planets, informed in part, by these new discoveries. In particular, there appears to be a preference for detecting H-alpha from protoplanets in the range 37¡inclination¡52 degrees with respect to our line of sight. We speculate why that is with a new theory evoking the largest possible vertical structures on exoplanets –with detailed illustrated magnetospherical accretion and cloud models. We will briefly highlight the exciting new hardware upgrades to MagAO-X's H-alpha SDI mode and how they should open even more exploration space for the discovery of even lower mass (or closer in ¡100 mas) protoplanets. We will end the talk by looking out towards the future of ELT visible ExAO with the high contrast H-alpha imager GMagAO-X currently undergoing its funded final design review (FDR) for first light at the GMT 25.4m telescope.

AMIGO and the James Webb Interferometer

Louis Desdoigts (Leiden University)

The James Webb Space Telescope (JWST) hosts a non-redundant Aperture Masking Interferometer (AMI) in its Near Infrared Imager and Slitless Spectrograph (NIRISS) instrument, providing the only dedicated interferometric facility aboard — orders of magnitude more capable than any interferometric experiment previously flown. However, the imaging performance of AMI at high contrasts has not met design expectations. A major contributing factor has been the presence of uncorrected detector systematics, notably charge migration effects in the H2RG sensor, and insufficiently accurate mask metrology. Here we present AMIGO, a data-driven calibration framework and analysis pipeline that forward-models the full JWST AMI system — including its optics, detector physics, and readout electronics — using an end-to-end differentiable architecture implemented in the JAX framework and in particular exploiting the dLUX optical modelling package. AMIGO directly models the generation of up-the-ramp detector reads, using an embedded neural sub-module to capture non-linear charge redistribution effects, enabling the optimal extraction of robust observables, for example kernel amplitudes and phases, while mitigating systematics such as the brighter-fatter effect. We demonstrate AMIGO's capabilities by recovering the AB Dor AC binary from commissioning data with high-precision astrometry, and detecting both HD 206893 B and the inner substellar companion HD 206893 c: a benchmark requiring contrasts approaching 10 magnitudes at separations of only 100 mas. These results exceed outcomes from all published pipelines, and re-establish AMI as a viable competitor for imaging at high contrast at the diffraction limit. AMIGO is publicly available as open-source software community resource.

Exoplanet Imaging with Large Segmented Telescopes: On-Sky Results from using Keck as a Testbed for Next Generation Telescopes

Maissa Salama (University of California, Santa Cruz)

Directly imaging an Earth-like planet requires reaching contrast levels better than 10^{-8} (around low-mass stars) to 10^{-10} (around Sun-like stars), which will be the goals of the next generation of ground based Extremely Large Telescopes (ELTs) and NASA's next flagship mission, the Habitable Worlds Observatory (HWO). A key technical barrier to reaching such deep contrasts is reducing the residual wavefront error in the presence of a segmented primary mirror. Keck Observatory is the only facility equipped with all of the hardware components, at full-scale, necessary for validating segment phasing strategies for the next generation of ground and space telescopes. In particular, the large segmented primary mirror, capacitive edge sensors, deformable mirror (DM), Zernike wavefront sensor (ZWFS), and high contrast science instruments, allow us to measure the impact of different wavefront sensing and control strategies on real on-sky science data. The ZWFS is ideal for measuring phase discontinuities such as segment co-phasing errors and the low wind effect. Here we report on contrast improvements measured on-sky with the Keck NIRC2 vortex coronagraph using the ZWFS to control the primary mirror segments. We also discuss ongoing developments of our goal to enable joint control of the primary mirror and DM to take full advantage of the ZWFS setup and correct different sources of aberrations, in parallel with science observations. The improved high-contrast performance on Keck from the ZWFS enables us to search for new exoplanets in the more abundant lower-mass, closer-in planet population. I will also present on direct imaging observations for a survey of young, nearby, low-mass stars that we are currently conducting, searching for new exoplanet and brown dwarf companions.

Extreme Adaptive Optics on the path to the ELT(s)
Markus Kasper (ESO)

Extreme Adaptive Optics (XAO) is widely used at current 8-m class telescopes to power high-contrast imaging instruments mostly dedicated to the observation of self-luminous Exoplanets and circumstellar disks. I will review the current systems and briefly introduce upgrades planned for the near future. The next generation of 30-40 meter class telescopes will literally open new worlds as direct imaging of Earth-like Exoplanets will come into reach. For this demanding science case, the XAO must push the residual halo at small angles down by orders of magnitudes below what is currently reached for the 8-m telescopes. New developments are needed in key AO technologies such as DMs with tens of thousands of actuators, fast RTCs supporting advanced control methods, and wavefront sensors with superior sensitivity and the capability to sense phase discontinuities in segmented apertures. I will review current activities in these areas and finish the talk with a first prediction of the Exo-Earth imaging capabilities of the XAO-powered Planetary Camera and Spectrograph (PCS) instrument for the ELT.

Use the 4S: A systematic re-analysis of VLT/NaCo data with Explainable Machine Learning
Markus Johannes Bonse (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.

High Contrast Imaging and Spectroscopy with JWST: Methods, Performances, and Lessons for the Future
Marshall Perrin (STScI)

The most recent Spirit of Lyot meeting took place just as JWST was completing commissioning and about to begin science operations. Since then JWST's unprecedented sensitivity, exceptional stability, and highly capable instrument suite have enabled transformative discoveries across so much of astronomy. In this talk I will review JWST's capabilities for high contrast studies of exoplanetary systems, describe methods, achieved performances, and lessons learned, and highlight key areas for continued effort. In addition to JWST's coronagraphy and aperture masking high contrast modes, observations using imaging spectroscopy and even simple direct imaging (without coronagraphy) are proving to be powerful tools for studying the environs of bright stars. I will discuss the aspects of JWST's observatory design and capabilities that enable these performances, and conversely some aspects that are less ideal, or pose practical challenges that must be addressed via data processing. We are still in the early days of using JWST to seek out and characterize exoplanets and their atmospheres, study the structures of circumstellar disks, and investigate the demographics and formation pathways of planetary systems.

Dynamical Analysis of the HD 169142 Planet-Forming Disk
Miles Lucas (University of Arizona)

We present a dynamical analysis of the HD 169142 planet-forming disk based on high-contrast polarimetric imaging over a twelve-year observational period, offering insights into its disk evolution and planet-disk interactions. This study explores the evolution of scattered-light features and their relationship with millimeter continuum emission. Archival visible-to-near-infrared scattered-light observations from NACO, SPHERE, and GPI combined with new observations from SCExAO reveal persistent non-axisymmetric structures in both the inner and outer rings of the disk. Through Keplerian image transformations and phase cross-correlation techniques, we show that the azimuthal brightness variations in the inner ring follow the local Keplerian velocity, suggesting these are intrinsic disk features rather than planet-induced spirals or shadows. The motion of the outer ring is weakly detected, requiring a longer observational baseline for further confirmation. Comparing scattered-light features with ALMA 1.3 mm-continuum data, we find that the scattered light traces the edges of dust structures in the inner ring, indicating complex interactions and a leaky dust trap around the water-ice snowline. These findings highlight the capability of long-term monitoring of circumstellar disks to distinguish planetary influences from Keplerian disk dynamics.

Old Data, New Planet: Finding Candidate Companions from the Gemini Planet Imager Exoplanet Survey
Nathalie Jones (Northwestern University)

The Gemini Planet Imager Exoplanet Survey (GPIES) was a direct imaging program aiming to observe 600 young, nearby stars to search for giant planets between 10-100 au. The survey took place between 2014-2019 and resulted in the discovery of a new planet – 51 Eridani b. However, many unconfirmed candidates remain from the survey from the forward-model matched filtering (FMMF) planet detection algorithm. This algorithm allows increased planet detection sensitivity by accounting for distortions in the image when fitting for the planet signal. We have been systematically analyzing all remaining candidates from the FMMF algorithm. Spectra are extracted from each detection and are used to identify the most promising planet candidates. This is achieved by comparing the data with empirical spectra of brown dwarfs and theoretical exoplanet atmosphere models. I will present the latest results from the validation of remaining GPI candidates and, in particular, the detection of HD 143811 AB b, a surprise discovery of a unique system. This new planet is only the second discovered by GPI and is one of only a few directly imaged planets orbiting a tight inner binary. I will share how this system is an excellent laboratory to study planet formation mechanisms through orbital monitoring and the current characterization of both planet and host binary. Lastly, I will discuss how the final vetting process leads to contrast curves for GPIES. Contrast curves, set by detection false positive rate, will demonstrate the impact of GPI on the direct-imaging field and on population statistics of young, Jovian exoplanets.

Getting ready for early high-contrast imaging at the ELT with METIS
Olivier Absil (University of Liège)

METIS, the mid-infrared ELT imager and spectrograph, is one of the first two science instruments that will be installed at the Extremely Large Telescope (ELT). Currently in its manufacture, assembly, integration and test phase, METIS is expected to see first light in early 2030. One of its prime scientific goals is to detect and characterise exoplanets and circumstellar disks through high-contrast imaging and spectroscopy. After reviewing the main design choices that will enable high-contrast imaging with METIS, I will describe the main challenges that the instrument will face to achieve deep contrasts. I will particularly highlight the effect chromatic aberrations due to water vapour seeing in the mid-infrared, as well as other sources of variable non-common path aberrations (NCPA) such as chromatic beam wander. I will then outline our strategy to measure and correct for variable NCPA based on focal-plane images, using a combination of an asymmetric pupil mask and supervised deep learning. After giving a short review of the on-going procurement and performance testing of high-contrast components, including vortex phase masks and apodisers, I will conclude this presentation by discussing the predicted on-sky performance of METIS using end-to-end simulations, and illustrate how it will impact exoplanet science in the 2030s with a couple of examples, such as the search for temperate rocky planets around nearby stars.

Fireworks around Fomalhaut: Planetesimal collisions directly imaged with Hubble
Paul George Kalas (UC Berkeley)

Collisions play a crucial role in the evolution of planetary systems, yet they are infrequent, short-lived, and thus nearly impossible to witness in real time. Here we present new observations with HST showing the sudden emergence of a point source in Fomalhaut's outer dust belt, resembling the original appearance of Fomalhaut b two decades ago. This newly detected source is likely a massive but unresolved dust cloud generated by a recent collision between planetesimals, offering rare and valuable insights into collisional dynamics. Such events could occur in any system with orbiting planetesimals and for many years may mimic the observational signatures of a planet reflecting starlight.

Exoplanet science with MICADO at the ELT: Simulations, challenges, and first-light strategies
Paulina Palma-Bifani (LIRA, Observatoire de Paris)

As part of the MICADO consortium and the MORFEO science working group, we are preparing for the next era of exoplanet observations with the Extremely Large Telescope (ELT). MICADO is expected to be the first instrument on-sky at the ELT and, notably, the first near-infrared spectrograph, making it a crucial tool for early scientific breakthroughs. In this talk, I will present our end-to-end simulation framework tailored to MICADO. Specifically, we use the single-conjugate adaptive optics mode (SCAO) and the long-slit with the simultaneous H+K band filter to recreate temporal scanning spectroscopy observations in pupil-tracking mode. This configuration opens exciting possibilities for exoplanet characterization, combining high angular and spectral resolutions (R=20000), allowing us to reach a high contrast. Our simulations incorporate realistic point spread functions (PSFs) generated with the Python code MISTHIC (Huby et al. 2024), including key observational effects such as atmospheric turbulence, dispersion, and static aberrations. From there, we generate a 4-dimensional data product, which replicates the output of MICADO's temporal scanning mode. We have optimized an algorithm to analyze this data product, specifically to simultaneously model the stellar and planetary components of the observations and recover the most likely planetary parameters in a statistical way using forward models. This algorithm will be hosted on GitHub as open-source code to support further simulations and to include community feedback, aiming to make it robust for performing data reduction at first light. Finally, I will discuss how these simulations will inform target selection and observing strategies. In detail, we aim to answer essential questions like: How close to the host star, and at what contrast, can we confidently retrieve atmospheric spectra? Which targets are ideal for MICADO to observe? What physics, imprinted in the atmospheres of young giant planets, will we be able to test?

Multiwavelength Interferometric Observations of Hot Dust in Three Extreme Debris Disks: HD172555, HD113766, and Eta Corvi

Philippe Priolet (IPAG, Grenoble, France)

The presence of hot dust in the inner regions of exoplanetary systems is common, with a detection rate of about 20% around nearby AFGK stars from near-infrared interferometric surveys. Excessive amounts of dust in the inner regions of planetary systems could affect the imaging of habitable planets in the future (notably an exo-Earth), justifying the interest of space agencies in this subject (e.g. https://exoplanets.nasa.gov/exep/exopag/sag/ SAG23, NASA Exoplanet Program). This hot dust is thought to be composed of small sub-micron sized grains close to their sublimation region. However, these small dust grains should be blown out by radiation pressure and a collisional cascade in situ is not sustainable in these inner regions over the lifetime of the system. Therefore a different production mechanism must be proposed to explain the presence of these grains. We focus on three extreme debris disks — HD172555, HD113766, and Eta Corvi — which stand out for their unusually high levels of warm dust. For Eta Corvi, the hot component might originate from inward-scattered exocomets, possibly misaligned with the outer cold belt, HD172555 shows mineralogical evidence consistent with a violent collision, while HD113766 represents a complementary case where both exocometary and collisional scenarios remain plausible. To constrain the spatial distribution, variability, and spectral energy distribution of this hot dust, we obtained multiwavelength interferometric data with VLTI/PIONIER (H band), GRAVITY (K band), and MATISSE (L, M, and N bands). In this contribution, we present the ongoing analysis of these datasets and the methods developed to extract spatial and spectral constraints on the dust. These preliminary results provide new insight into some of the mechanisms sustaining extreme levels of hot dust in planetary systems.

Laboratory Update for the AstroPIC Integrated Photonic Coronagraph

Rachel Morgan (SETI/NASA Ames)

Integrated photonics is a promising coronagraph technology option for increasing the Exo-Earth science yield of NASA's Habitable Worlds Observatory flagship. A photonic integrated circuit (PIC) coronagraph is theoretically capable of achieving better performance than traditional bulk-optic coronagraphs because arrays of integrated interferometers can be combined to implement any linear operator, which provides a practical way to implement a near-optimal coronagraph operator. The tunability of integrated photonics also has the flexibility to adjust parameters for better operation under changing conditions and objectives. However, photonic coronagraphs require significant maturation to be ready for a space telescope mission. The AstroPIC project is advancing this technology by developing a proof-of-concept integrated photonic coronagraph based on silicon photonics technology for the near-infrared. In this talk, we will review the design of AstroPIC and present results from laboratory testing of the first set of PIC devices fabricated for the project, including experiments that achieve over 90 dB extinction (¡1e-9 contrast) of a single input channel. We will describe the development of a PIC coronagraph testbed at NASA Ames that can emulate the coupling from an HWO-like telescope pupil into the PIC through an array of lenslets and grating couplers. We will also discuss the development of system-level simulation tools to predict the performance of the instrument and feed into scientific yield estimations for HWO Exploratory Analytic Cases (EACs) 1-3.

Extreme dust size segregation in HD 21997: Constraining the origin of gas in debris discs with JWST and ALMA

Raphael Bendahan-West (University of Exeter)

ALMA observations over the past decade have revolutionised our understanding of debris discs, imaging them at unprecedented sensitivity and revealing that many young discs contain vast amounts of CO gas. However, the origin of this gas remains uncertain: it could be primordial, dominated by remnant unseen H2 gas from the protoplanetary disc phase, or secondary, where CO gas is produced by ongoing destruction of volatile-rich planetesimals. In these gas-rich systems, small dust grains appear significantly shifted outward compared to large grains, beyond what radiation forces alone predict. This spatial segregation of dust of different sizes could be explained by gas drag driving the outward migration of small grains. Crucially, how far small grains migrate depends on their collisional lifetime and the gas surface density, providing a diagnostic tool to distinguish primordial from secondary gas origins. In this talk, I will present JWST NIRCam and MIRI coronagraphic observations, the first scattered-light detection of the archetypal gas-rich disc around HD 21997. While ALMA traces the large grains concentrated between 60 and 120 au, JWST reveals small grains peaking at 150 au, demonstrating a remarkable 60 au radial offset and the most extreme size-dependent spatial segregation observed in any debris disc to date. I will demonstrate how the synergy between ALMA and JWST enables us to dynamically constrain the amount and origin of gas present in this gas-rich debris disc through dust migration models, providing crucial insights into how gas shapes the architecture of young planetary systems and influences the final stages of planet formation.

Proba-3 precision formation flying mission: an in-orbit success
Raphael Rougeot (European Space Agency)

Proba-3 is the European Space Agency's pioneering precision formation flying mission, embarking on-board the giant externally occulted solar coronagraph ASPIICS. One spacecraft carries an occulter disc of 1.42m diameter in front of the Sun, that casts its shadow onto the 5cm aperture of a Lyot-style coronagraph aboard a second spacecraft that is positioned at 144m behind with millimetric accuracy. This formation is actively maintained in orbit for six hours per revolution. Launched in December 2024, the Proba-3 satellites entered routine science operations in July 2025 following a successful commissioning phase, marking a world-first achievement for formation flying mission concept. Since then, ASPIICS has been delivering crucial white light observations of the solar corona in the rather unexplored region from 1.1 to 3.0 solar radii. Achieving the required high-contrast, low straylight and high-resolution close to the solar limb has been made possible by two key factors: the coronagraph instrument design, and the large formation baseline controlled to millimetric precision. This paper first presents the Proba-3 mission and its concept. Second, it reports on the in-orbit performance of the formation flying system. Finally, it provides an overview of the in-flight end-to-end performance of ASPIICS, demonstrating the scientific potential of formation flying.

Towards a system-level coronagraphic demonstration for the Habitable Worlds Observatory
Remi Soummer (STScI)

The Habitable Worlds Observatory (HWO) will require a fully integrated system for high-contrast imaging of Earth-like exoplanets. To advance the Technology Readiness Level (TRL) of this critical capability, our group has developed the High-contrast Imager for Complex Aperture Telescopes (HiCAT) to enable a system-level demonstration of coronagraphy with segmented apertures. The testbed incorporates Classical Lyot, Apodized Pupil Lyot and Phase-Apodized Pupil Lyot coronagraph modes, continuous deformable mirrors for wavefront control, and a truly segmented, controllable deformable mirror as the telescope simulator. We have achieved contrasts ranging from of 1e-8 in monochromatic light to 6e-8 (90% CI) in a 9% bandpass dark hole extending from $4.4\lambda/D$ to $11\lambda/D$. HiCAT demonstrated both open-loop stability and dark hole stabilization using high- and low-order wavefront sensing and control loops, and under low-order and segment-level drifts. These results represent the only demonstration to date of high-contrast coronagraphy with a truly segmented aperture, currently limited to ambient conditions. To prepare for more realistic technology demonstrations for HWO, including a full hardware system at 1e-10 contrast in vacuum, we are now developing ASSIST (Active Segmented Surrogate for Integrated Systems Tests). ASSIST is a laboratory segmented telescope ($\sim$1 inch segments) that constitutes a crucial component of such a system demonstration as it can be integrated with high-contrast testbeds such as HiCAT or future vacuum testbeds to provide more realistic input and segment control. ASSIST features an off-axis optical design and three-degree-of-freedom actuation via piezoelectric actuators with custom electronics. Our current prototype, featuring a 7-segment flat mirror, has been evaluated in vacuum for static alignment, and its dynamic stability in closed loop will be tested in a vacuum experiment using a Zernike interferometer under development. We present plans and designs for a full 7-segment telescope ASSIST, including primary and secondary mirrors, illumination telescope, wavefront sensor and imaging camera.

Results from the WIde Separation Planets In Time (WISPIT) survey
Richelle Felicia van Capelleveen (Leiden Observatory)

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 from the 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 $\sim$16 Myr binary with a solar-type primary that hosts a $\sim$10 Jupiter mass and $\sim$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 a $\sim$5 Myr solar analogue that hosts a spectacular multi-ringed disk and a $\sim$5 Jupiter mass embedded planet, WISPIT 2b. This planet marks 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. In addition to published results, we will present updates on the second epoch observations of 88 targets starting in October 2025.

SUPPPPRESS: Developing low-leakage liquid-crystal vector vortex coronagraphs for space-based exoplanet imaging
Rico Landman (NOVA)

We report on the results of the ESA-funded “SUPPPPRESS” project, which aims to develop high-performance liquid-crystal coronagraphs for the direct detection and spectral characterization of Earth-like planets in the habitable zone with future space telescopes. The project focuses on improving the contrast and increasing the operational spectral bandwidth of the Vector Vortex Coronagraph (VVC). We manufacture regular and multi-grating VVCs (mgVVCs), consisting of a two- or three-element stack of vortex and grating patterns, to significantly reduce the impact of polarization leakage and enabling us to fully exploit its achromatic and scale-invariant properties. In this presentation, we discuss the (mg)VVC manufacturing and testing within the SUPPPPRESS project. We detail the improved manufacturing of multiple liquid-crystal masks (LCMs) by ColorLink Japan, Ltd. and their quality assessment with a newly developed far-field diffraction setup, polarization microscopy, and zero-order leakage spectroscopy. We report on the assembly of individual LCMs into mgVVCs with a custom alignment and bonding jig. Moreover, we demonstrate their broadband contrast performance on the THD2 testbed in Paris, where we compare standard VVCs, and double- and triple-grating VVCs with and without leakage filtering to perform a trade-off. Finally, we will show the results of space environmental qualification tests for the manufactured LCMs.

From data-drive to physics-based: exoplanet imaging via differentiable optical models
Rodrigo Ferrer-Chavez (Northwestern University/CIERA)

One of the main limitations for exoplanet high-contrast imaging is removing starlight from our data to reveal faint astrophysical signals. As advances in instrumentation increase the sensitivity of our observations, it is crucial to develop sophisticated data analysis techniques that allow us to access the full sensitivity of our instruments. Current post-processing methods systematically fall short of this, being unable to completely remove starlight from our observations and leaving astrophysical signals undetected even though they are within theoretical reach of our telescopes. A notable weakness of these methods is that they are agnostic to the image formation process: they model the star point spread function (PSF) by combining many reference images (e.g. of other stars, or the same star at different roll angles). Incorporating information about the imaging process has the potential to produce higher accuracy PSF models, and therefore better sensitivity. We present a physics-informed framework that models the star PSF by simulating light propagation through the optical system, naturally leveraging the image formation process and wavefront sensor data in the PSF estimation. By using state-of-the-art optimization techniques from the machine learning community such as automatic differentiation, we efficiently fit millions of free parameters in our model in only $\sim$10 minutes to produce excellent PSF fidelity. Our method simultaneously estimates the wavefront error in the telescope during the observation, with clear implications for instrument development and wavefront control. We show the effectiveness of our method recovering known planets from JWST data that yielded non-detections with traditional methods, and with a clear detection of a new planet candidate with JWST. We show how the flexibility of this framework makes it generalizable to a variety of instruments, making explicit use of existing instrument characterization efforts, and thus paving the way for improved exoplanet sensitivity in current and future facilities.

Socio-Demographic Insights into the Exoplanet Direct Imaging Community: A Follow-Up Study
Saavidra Perera (UCSD)

Recognizing and addressing under-representation, exclusion, and discrimination remain crucial in astronomy. In 2019, a first socio-demographic survey was conducted at the Spirit of Lyot conference. With this talk, we wish to present the results of a follow-up survey carried out at the 2022 edition in Leiden, with 96 responses (44% participation). The survey examined visibility at conferences, recognition in publications and projects, experiences of disrespect and inappropriate behaviors, and allyship with minorities, across factors such as career stage, gender, expatriation, under-represented identity, and parenthood. Respondents were more often from traditionally disadvantaged groups (women, non-permanent researchers). Results highlight biases against non-permanent researchers, who receive fewer invitations to organizing committees and fewer talks for PhD students. Inappropriate behaviors disproportionately affect women and non-binary people: 36% of female and non-binary PhD students report such experiences in the past 2.5 years, compared to 17% of male PhD students. Experiencing or witnessing disrespect strongly correlates with noticing it in others. On a positive note, 82% of respondents express willingness to engage in allyship. We conclude with recommendations to improve well-being and visibility of under-represented groups in astronomy.

Performance evaluation of ultraviolet coronagraphs for the Habitable Worlds Observatory
Saraswathi Kalyani Subramanian (University of Arizona)

The Habitable Worlds Observatory (HWO) is a planned NASA mission to “detect and characterize Earth-like extrasolar planets,” and one of its key goals is to search for signs of life on exoplanets. The presence of ozone in the atmosphere of these planets is a crucial biomarker, and it can be detected by the broadband absorption feature at near ultraviolet (NUV) wavelengths (200 - 350 nm). The HWO instrument suite could include a NUV coronagraph, but contrast limits in the NUV regime are not well understood. To assess the feasibility of a NUV coronagraph for HWO, we develop numerical models to evaluate contrast limits and robustness to low-order wavefront drift and dynamic segment modes for the first three EAC (Exploratory Analysis Configuration) aperture geometries and various coronagraph architectures including a Classic Lyot Coronagraph (CLC).

Designing the Observation Phase of the Nancy Grace Roman Space Telescope Coronagraph Instrument
Schuyler Wolff (The University of Arizona)

The Coronagraph Instrument onboard the Nancy Grace Roman Space Telescope is an important stepping stone towards the characterization of habitable, rocky exoplanets. In an observation phase conducted during the first 18 months of the mission (expected to launch in fall 2026), novel starlight suppression technology may enable direct imaging of a Jupiter analog in reflected light. The Community Participation Program Team aims to maximize the long-term value of the technology demonstration activities and datasets to the wider community. A white paper call in the summer of 2025 demonstrated community support for several key science themes and performance demonstrations. We will summarize the results of the call and the earlier community interest survey (January 2025). Both provided valuable inputs for the strategic planning of the Coronagraph Instrument mission. Finally, we will present the observation campaign design and priorities for the first 6 months of the on-sky Observation Phase.

Emerging technologies that bridge the HCI technology gap
Sebastiaan Haffert (Leiden Observatory)

The future of high-contrast imaging is very exciting. Upcoming observatories such as the Nancy Grace Roman Space Telescope and the Extremely Large Telescopes in the near future and Habitable Worlds Observatory in the slightly further future will fundamentally change the field of direct imaging. The community has developed a significant amount of technology to overcome the challenges of these new observatories. However, we still need to close several technology gaps to enable instruments at the fundamental limit. There are many new concepts that are emerging within the field of high-contrast imaging. From the development of optical metasurfaces and astrophotonics to quantum-optimal detection schemes. These push the hardware to their limits. Next to that there has been a tremendous development of algorithms for high-contrast imaging. We now have neural networks controlling extreme adaptive optics systems, ground-based dark hole digging and novel post-processing techniques. I will give an overview of the exciting developments from the past few years and place them in context for our future missions.

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4 years in metasurface development for exoplanet imaging at UC Santa Barbara
Skyler Palatnick (UC Santa Barbara)

As exoplanet direct imaging progresses towards lower planet-star contrasts and smaller, less separated planets, the need for technological improvement in imaging systems remains ever present. Metasurface optics, or arrays of subwavelength structures with highly tailorable geometry and composition on a thin substrate, have the potential to greatly advance coronagraph systems at various stages of the optical pipeline by correcting aberrations induced by other optical components and improving upon the performance of the conventional optics that are currently used. Metasurfaces can provide achromatic phase, amplitude, and/or polarization control in a compact package. They can also be designed to apply different manipulations to different polarization states of light, performing multiple optical functions simultaneously and independently. I will provide a brief overview of metasurface optics and discuss my efforts to design, fabricate, characterize metasurface coronagraphic masks, and (hopefully soon!) install these optics in ground-based instruments. I report on visible metasurface scalar vortex designs that achieve 10^{-8} contrast over 20% bandwidth in simulation, broadband in-lab contrast measurements of an H-band metasurface scalar vortex on the order of 10^{-5}, prototypes of a K-band metasurface scalar vortex to be installed in the SCALES instrument, and preliminary visible metasurface scalar vortex prototypes.

First Results from the OASIS Survey for Discovering and Characterizing Extrasolar Planets by Direct Imaging and Astrometry
Thayne Currie (UT San Antonio)

In this talk, I describe the first scientific results from the Observing Accelerators with SCExAO Imaging Survey (OASIS), the largest active exoplanet direct imaging survey. OASIS uses SCExAO/CHARIS high-contrast integral field spectroscopy and Keck/NIRC2 thermal infrared imaging to target 150 young stars whose Hipparcos and Gaia astrometry reveal dynamical evidence for an unseen substellar companion. The first OASIS discoveries include multiple new, confirmed discoveries of exoplanets and brown dwarfs: all with simultaneous atmospheric, orbital, and dynamical mass constraints absent from traditional surveys. Many of these stars have never been targeted in a planet search with any technique. Our results begin to hint at a new population of superjovian planets whose moderate eccentricities are distinct from many more closely-orbiting Jupiters or much more massive brown dwarfs. We describe preliminary new constraints on the atmospheric evolution of substellar objects as a function of mass from OASIS. Finally, we describe the critical role this program plays in supporting the Roman Space Telescope Coronagraphic Instrument. OASIS has now provided the first demonstrably suitable system for Roman Coronagraph technology demonstration and a population of substellar companions whose retargeting with Roman will provide key tests of the coronagraph's capabilities and our ability to extract planet properties from optical spectra. OASIS is generously supported by Subaru/NAOJ and the National Science Foundation for its scientific merit and NASA HQ for its support of the Roman Coronagraph.

Direct imaging discovery of a young giant planet orbiting on solar system scales
Tomas Stolker (Leiden University)

HD 135344 is a visual binary system that is best known for the protoplanetary disk around the secondary star. Various substructures, such as a cavity and spiral arms, point to ongoing planet formation, but putative planets have remained hidden. The circumstellar environment of the A-type primary star, on the other hand, has evolved faster as inferred from the absence of accretion and high infrared excess. I will present the discovery of a young giant planet in orbit around HD 135344 A. This object is one of the youngest directly detected planets that has fully formed and orbits on solar system scales. I will show results on the first characterization of its atmosphere, bulk parameters, and orbit, based on 4 years of VLT/SPHERE and VLTI/GRAVITY data. I will also discuss the challenges that we faced to disentangle orbital from background motion. HD 135344 Ab provides a unique window to a young giant planet shortly after formation, without any obscuration by circumstellar dust. The HD 135344 binary system shows that planet formation and disk evolution timescales can differ for two coeval stars within the same environment.

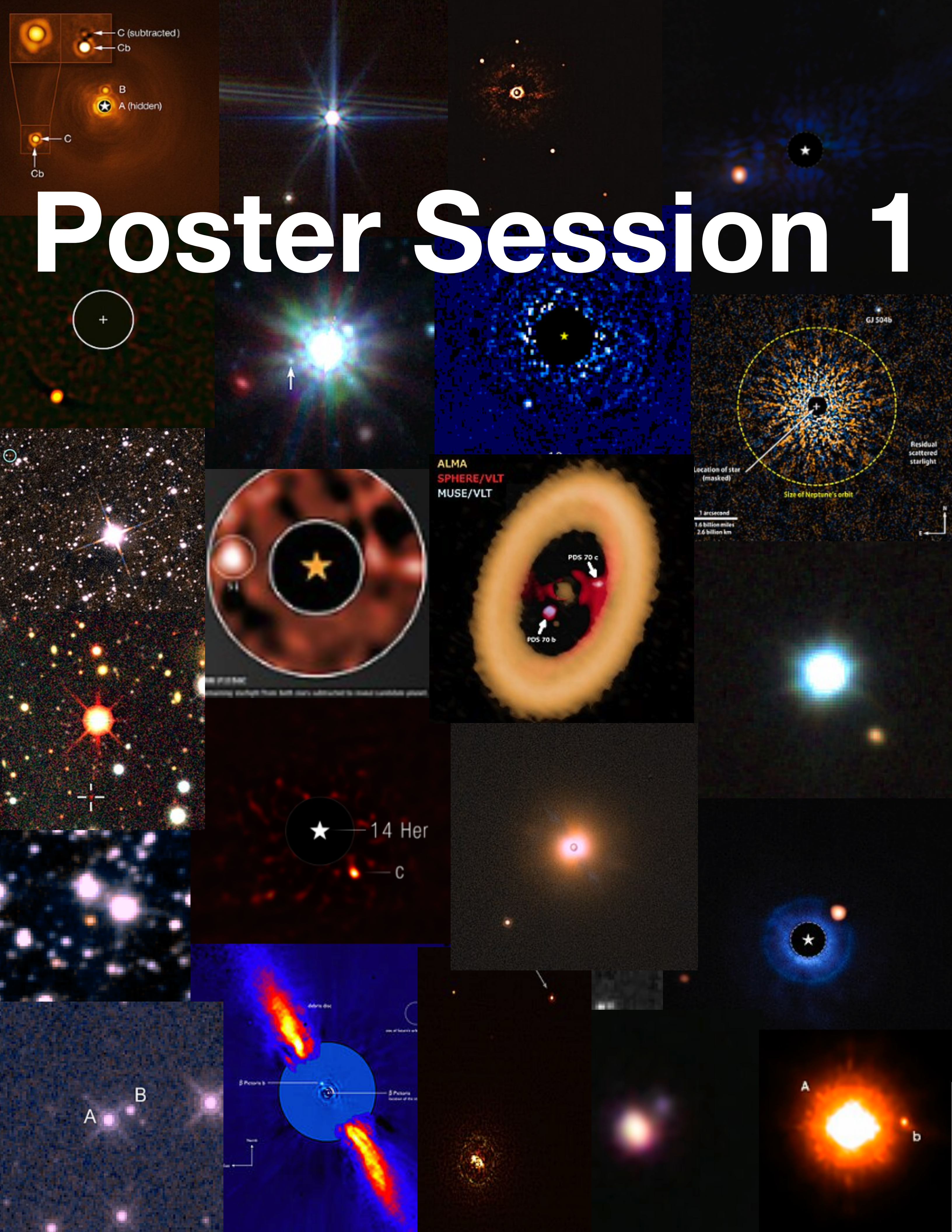
New perspectives on Disks around Planetary-mass Companions from JWST/MIRI
Ya-Lin Wu (National Taiwan Normal University)

Circumplanetary disks play a crucial role in regulating the mass accretion and angular momentum transport of giant planets. A comprehensive understanding of their properties may offer new insights into planet formation. Disks surrounding wide-orbit planetary-mass companions (PMCs) are of particular interest, as they can be readily observed with infrared and radio facilities. Previous ALMA observations have shown that PMC disks are faint, making it more effective to detect them at mid-infrared wavelengths and characterize their bulk properties at a population level. We perform 5-21 micron imaging of young accreting PMCs with JWST/MIRI and model their spectral energy distribution to constrain disk temperature and geometry. The presence of the 10 micron feature is also examined, and its implications for grain growth and disk evolution are discussed.

On-sky demonstration of subdiffraction-limited measurements using a photonic lantern
Yoo Jung Kim (University of California, Los Angeles)

We present the on-sky demonstration of using a photonic lantern for high-angular-resolution astronomical spectroscopy. A photonic lantern (PL) is a fiber-based mode-converter that splits the focal-plane light into multiple single-moded outputs. The relative intensities between the outputs are very sensitive to small angular scales, effective for high-angular-resolution measurements, but the sensitivity makes it highly susceptible to low-order wavefront errors. Thus, dedicated observation strategies and post-processing techniques are necessary to isolate the astronomical signals from wavefront errors. Here, we introduce a novel calibration strategy that filters out tip-tilt errors, leveraging simultaneously recorded focal-plane images and using a spectral-differential technique that self-calibrates the data. Observing the classical Be star β CMi using the FIRST-PL 19-port PL-fed spectrometer at the Subaru Telescope, we detected spectral-differential spatial signals and reconstructed images of its Hα-emitting disk. We achieved an unprecedented Hα photocenter precision of 50 μas in about 10-minute observation with a single telescope, measuring the disk's nearside-farside side asymmetry for the first time. This work demonstrates the high precision, efficiency, and practicality of photonic mode-based imaging techniques to recover sub-diffraction-limited information, opening new avenues for high angular resolution spectroscopic studies in astronomy. We will talk about lessons learned and directions for future PL-fed spectrometers.

Poster Session 1



2 Poster Presentations: Session 1

High-fidelity wavefront correction simulation tools for the Roman Coronagraph
A J Eldorado Riggs (JPL)

On the path to imaging and characterizing terrestrial exoplanets with NASA's flagship Habitable Worlds Observatory, the Roman Space Telescope's Coronagraph Instrument will demonstrate several high-contrast imaging technologies in space for the first time. These include two types of coronagraphs, large format deformable mirrors, low- and high-order wavefront sensing and control (LOWFSC and HOWFSC) loops, and photon-counting detectors. The single, top-level requirement for the instrument is to demonstrate a broadband dark zone at high contrast. The Community Participation Program (CPP) is investigating a range of scientific and engineering activities to perform after that requirement is met. To facilitate accurate modeling of these CPP activities, the Hardware Working Group is developing the corgihowfsc software package in Python on GitHub. The corgihowfsc repository is a wrapper that combines several official code repositories open-sourced by the Roman Coronagraph: corgisim (which is a wrapper around the CGISim package) for producing simulated images from instrument, cgi-howfsc for performing HOWFSC, cgi-eetc for calculating engineering exposure times, and cgi-coralign for performing optical calibrations and construction of the HOWFSC model. The current goals for corgihowfsc are to provide working HOWFSC simulations of all twelve originally included coronagraph modes (required, best effort, and contributed) and the framework for the CPP to investigate new, so-called "enhanced" modes. By using the official modeling tools, the results and software produced by the CPP will be the highest possible fidelity and more easily incorporated back into mission planning.

STARLITE Monochromatic Simulations: Coronagraphic Performance, DM Control, and Contrast Estimates
Adam Johnson (NRC-HAA)

Direct imaging of Earth-like exoplanets in the visible requires coronagraphic contrasts on the order of $10^{1}0$ at separations of a few λ/D, demanding sub Angstrom-level wavefront control that is currently not achievable from the ground with existing techniques. The STARLITE (Superluminous Tomographic Atmospheric Reconstruction with Laser-beacons for Imaging Terrestrial Exoplanets) concept aims to address this challenge by employing a space-based satellite constellation to generate ultra-bright off-axis laser beacons for tomographic reconstruction and adaptive optics correction on 8–30 m class telescopes. In this study, we extend the STARLITE end-to-end simulation framework to include a representative coronagraph and a deformable mirror model with realistic actuator geometry, fitting error, and spatial-frequency limits. Simulations are carried out in monochromatic light to reconstruct the incoming wavefront from beacon measurements, apply closed-loop correction, propagate the corrected field through the coronagraph, and quantify the residual error. From these results we evaluate the achievable raw contrast at the focal plane and the extent to which post-processing can improve detection sensitivity, with goals in the 10^8–10^9 range. This study represents the next step in developing the STARLITE concept, demonstrating its potential as a unique path to high-contrast visible-light exoplanet imaging from the ground.

Old Planets, New Tricks: Making Archival Data Work for Direct Imaging of Mature Giant Exoplanets
Alexander Venner (Max Planck Institute of Astronomy)

As imaging instruments for exoplanet detection continue to improve, we are seeing increasing potential for synergy between imaging and the older indirect methods of radial velocity and astrometry. Whereas at present this "triple synergy" is mainly limited to the most massive and long-period giant planets, future instruments such as the Nancy Grace Roman Space Telescope (Roman) Coronagraph Instrument and the Habitable Worlds Observatory will deliver the unprecedented capability to reveal genuine Jupiter analogues in reflected light, unveiling a whole new parameter space for direct imaging. The best of these mature imaging targets lie close to the Sun, meaning that the stars typically have rich archival RV and astrometry datasets. Efficient leveraging of these resources will therefore be critical for the success of future efforts in the imaging of mature giant exoplanets. Here I will present results from an ongoing effort to combine archival radial velocities and Hipparcos-Gaia astrometry to characterise the orbits of known nearby long-period giant exoplanets. The combination of both types of data allows for direct constraints on orbital inclinations, providing information on the planetary projected separation and position which are vital for successful execution of direct imaging observations. I will place particular emphasis on the implications of these results for the Nancy Grace Roman Space Telescope, expected to launch during 2026.

Roman Coronagraph Ground Loop Operations

Alexandra Greenbaum (Caltech/IPAC)

The Nancy Grace Roman Space Telescope Coronagraph Instrument will exercise key technologies in high contrast imaging, and provide a stepping stone to future earth-analog imaging with the Habitable Worlds Observatory. The Coronagraph Instrument represents a unique opportunity to gain experience operating in the extremely high star-to-companion flux ratio regime, from planning and scheduling to interpretation of data and instrument performance. High contrast ($< 10^{-7}$) is achieved through an active High Order Wavefront Sensing and Control (HOWFSC) system, which incorporates the Roman Ground System in a real time data processing, analysis, and commanding loop. The Roman Science Support Center (SSC) at IPAC carries out the real time commanding and data processing for HOWFSC, as well as creating the infrastructure for CGI scheduled observations, monitoring the instrument, and processing and managing data products. This presentation describes the operation of the HOWFSC ground loop from the control center at IPAC, highlighting key testing milestones and timing and processing details.

CAPyBARA: a fast, robust Roman CGI-like simulator for exploring WFSC, observing, and post-processing strategies

Alexis Lau (LAM, Marseille)

The Roman Space Telescope Coronagraphic Instrument will be the first spaceborne coronagraph to demonstrate active wavefront control and high contrast imaging in reflected starlight, targeting contrasts of 1e-7 or better at 3–9 λ/D. Although this performance is a major step toward future exo Earth imaging, ultimate detection limits will be set by temporal wavefront changes between science and reference observations, which constrain the effectiveness of post processing. To understand and mitigate these effects, we need flexible simulation tools that can rapidly explore observing strategies, wavefront sensing and control algorithms, and post processing pipelines before moving to high fidelity simulators or testbed experiments. We present CAPyBARA, a fast, robust open source simulator built in Python with HCIPy. CAPyBARA models simplified Roman CGI optics and propagation with tunable Zernike aberrations that can be imported from OS11 products or customized by the user. Its modular design enables rapid testing of wavefront sensing and control techniques, observing scenarios, and analysis methods, bridging the gap between lightweight numerical experiments and full scale simulators or hardware. This framework lets the community probe the trade space and quantify performance on timescales of minutes rather than days. As a demonstration, we used CAPyBARA to evaluate high order dithering strategies prior to implementation on the HiCAT testbed, providing confidence that the approach would yield measurable gains. By offering a flexible and accessible platform for rapid experimentation, CAPyBARA can accelerates the development of observing and post processing strategies for Roman CGI and informs future mission design studies.

Thermal Structural and Optical Analyses of a Balloon-Borne Coronagraphic Imaging System

Ananya Sahoo (University of Massachusetts, Lowell)

We present thermal, structural and optical performance analysis for the Planetary Imaging Coronagraph Testbed Using a Recoverable Experiment for Debris Disks (PICTURE-D) testbed, which is a NASA balloon-borne observatory to image and characterize dust and debris disks around nearby stars in reflected visible light using high-contrast imaging techniques. Key components of PICTURE-D include a 60 cm off axis telescope, a vector vortex coronagraph to suppress the stellar light, and two MEMS based deformable mirrors for stabilizing the wavefront and a creating a dark zone surrounding the host star. Thermally induced mechanical deformation of the observatory presents key challenges to the stability of wavefront and limits the performance of coronagraph. Using an integrated finite element model of observatory plus the coronagraph, we model the thermo-structural evolution of the observatory at a 35-40 km float altitude using temperature data available from the recent flight and assess the final coronagraphic performance of the instrument in the balloon flight environment.

Independent Verification of Transiting Planet TOI 201 c with Hipparcos-Gaia Astrometry
Andre Fogal (University of Victoria)

TOI 201 is an F6-7 dwarf targeted by the Transiting Exoplanet Survey Satellite (TESS). A known warm Jupiter in the system, TOI 201 b, was previously discovered via transits throguh TESS light curves. A recent reanalysis of the light curves revealed transit timing variations suggested to come from ∼14 Jupiter mass companion on an ∼8 year eccentric orbit, dubbed TOI 201 c, which was later shown to also transit the host star. We present an independent signal from TOI 201 from a novel analysis of Hipparcos-Gaia absolute astrometry that reveals a companion consistent with the mass and orbit of planet c. We will present results from Bayesian inference with the astrometry signal to independently confirm and further constrain the planetary and orbital parameters. This system represents a unique case of independent detection from both transit and astrometry data. With an apparent separation of ∼30 - 60 mas, this system also presents an exciting possibility of imaging with instruments such as VLTI/MATISSE or upcoming extremely large telescopes, which would make it one of the first transiting systems to also be directly detected.

First Spectroscopic Observations of Cold Planetary-mass Companion GJ 504 b with JWST/NIRSpec reveal high metal enrichment
Aneesh Baburaj (UC San Diego)

JWST has enabled spectroscopic observations of substellar companions too faint to observe from the ground. These include planetary-mass companions like GJ 504 b, an object which has been the subject of extensive debate regarding its mass and planetary nature but has proved too faint to observe using ground-based spectroscopy. In this talk, we present the first spectroscopic data for this companion, obtaining comprehensive coverage over the 3-5 micron range using moderate-resolution (R ∼ 2,700) observations with JWST NIRSpec. Our work demonstrates the first PSF subtraction using Angular Differential Imaging for NIRSpec, recovering the companion at S/N > 10 per spectral channel. The extracted G395H spectra show strong signatures of several molecular species, including H2O, CO, CO2, CH4, and NH3. CCF analysis of the spectrum confirms the presence of ammonia at a 7σ significance, the first unambiguous detection of the molecule in the near-infrared for a planetary mass companion. Joint retrieval modeling of the spectrum and previous photometry yields an effective temperature = 544±7 K, metallicity > 0.6 dex, strong constraints on disequilibrium chemistry, and constraints on cloud properties. While our modeling constrains the mass to above the deuterium burning limit, the highly super-stellar metallicity of GJ 504 b (0.3+ dex higher than the primary) strongly hints at its formation like a planet. The strong preference for clouds by our retrievals suggest that accounting for cloud absorption is needed to accurately model the spectra of high-metallicity late-T planetary-mass companions.

The Starchive – A Growing Resource for Direct Imaging Surveys
Angelle Tanner (Mississippi State University)

Have you struggled to find all the data you need to develop a robust sample for a direct imaging survey only to resort to Wikipedia along with five to fifty different references? Have you observed targets that you later realized where already observed in similar surveys but not reported as a non-detection? Have you accessed all the on-line data archives only to be frustrated with user interfaces designed for the original PIs and not the community? There's got to be a better way! Over the past few years, I have been assembling data and developing the web application for a resource I call the Starchive. The database currently contains over 56,000 objects, 430,000 fluxes and photometry, 236,000 coordinates, 1.6 million stellar, planet and disk parameters and 23,000 references. The two samples most related to direct imaging include stars within 30 parsecs and stars ¡1 Gyr in age. There are also sub-samples of brown dwarfs, white dwarfs and the current NASA Exoplanet Archive list of confirmed exoplanetary systems. The main web page has a filter, single and list search functions. When looking at a single star page, there are finder charts, an airmass chart, a spectral energy distribution with the photometry and a host of physical properties. When multiple stars are queried, the page contains a sortable, customizable, and downloadable table along with a set of different plotting tools in 2-D and 3-D. High contrast images, spectra and time series can be accessed there too. I have ingested the content of the DIVA archive and have included additional high contrast images from the community. I would love to discuss a path forward to including additional archival data including contrast plots. My poster will depict many of the features of the Starchive and I will be available for live demonstrations.

Mapping the Late Stages of Giant Planet Evolution with JWST Imaging of Benchmark Cold Planets Eps Ind Ab and Eps Eri b
Aniket Sanghi (Caltech)

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 $\sim$3.5 pc), Eps Ind Ab and Eps Eri b, are the most favorable targets for detailed comparative planetology studies with Jupiter and Saturn using JWST imaging and spectroscopy. I will present the first 4–25 um spectral energy distribution of a cold giant planet ($<$300 K). I use new NIRCam and MIRI photometry of Eps Ind Ab to empirically derive its bolometric luminosity, which, together with the planet's known dynamical mass, enables precision tests of substellar models at cold temperatures and mature ages. The 4–5 um photometry uniquely probes the presence of water clouds, a key prediction of low-temperature atmospheric models (only the third such observational test in a giant planet after TWA 7b and 14 Her c). Next, I will discuss new NIRCam observations aimed at imaging Eps Eri b for the first time. We achieve two times deeper sensitivity compared to previous JWST datasets at the expected planet location. Surprisingly, the planet remains undetected. I synthesize flux limits from the non-detection with an updated age estimate for the star and planet b's known planet dynamical mass to place new constraints on its bulk properties, which hint at greater similarity to Jupiter than previously known, and discuss its observability with Roman CGI.

Resolving Outer Giants with Gaia Astrometry, High contrast Imaging, and Radial Velocities
Anne-Marie Lagrange (CNRS/LIRA/Observatoire de Paris/PSL)

Giant planets act as system architects: they reshape disks, steer the assembly and long-term stability of inner rocky planets, and can channel volatiles inward—processes central to habitability. Their census and dynamical influence between $\sim$5 and 30 au—the realm of Jupiter and Saturn—remain however poorly mapped. Radial velocities loose leverage beyond $\approx$8 au and return only minimum masses, and high-contrast imaging has historically favored very young, massive companions at wide separations. Consequently, mature Jupiter/Saturn analogs are underrepresented. We address this gap by re-calibrating Gaia DR3 astrometric indicators (RUWE, AEN) and applying them systematically to diverse stellar populations. This approach reveals outer companions around young stars (Lagrange et al. 2024), debris-disk systems (Lagrange et al., in prep.), and nearby M dwarfs (Destriez et al., in prep.), including cases with known inner planets. Gaia data only provides degenerate solutions for the companions. By merging them with archival radial velocities and direct-imaging constraints (including JWST), we identify companions in the giant-planet/low-mass brown-dwarf regime. High contrast imaging, and in particular JWST coronagraphy or Gravity can provide detections or tighter upper limits that opens a parameter space in exoplanet discoveries. We will present Gaia + RV + high-contrast imaging results for a number of stellar populations, and show how extending the same synergy with DR4 will reshape the demographics and dynamics of giant planets, clarify their formation pathways, and deliver high-value targets for ELTs and future flagship missions.

Mid-infrared images of iconic directly imaged systems with JWST/MIRI.
Anthony Boccaletti (LIRA, Paris Observatory)

The MIRI instrument on board JWST now provides high-contrast imaging at mid-infrared wavelengths, opening an entirely new window for characterizing exoplanetary systems. We will present the first ∼3 years results obtained on known exoplanets observed in GTO programs, as well as new discoveries from GO programs. The GTO ExoMIRI programs targeted three iconic systems : HR 8799, HD 95086, and GJ 504, obtaining deep coronagraphic observations in four specific narrow band filters at 10.65, 11.40, 15.50 microns, plus a broader filter at 23 microns. All known planets in these systems are clearly recovered, allowing, for the first time, direct measurements of their mid-infrared fluxes. These data indicate larger planetary radii and cooler temperatures than previous near-IR estimates, aligning more closely with evolutionary models. The observations also provide the first spatially resolved view of the inner warm debris disks in HR 8799 and HD 95086. In addition, MIRI coronagraphy enables the first unambiguous detection of NH3 in GJ 504b, a key molecule for probing the atmospheres and surface gravity of cold exoplanets. An important achievement in the first GO observations is the fact that MIRI has demonstrated the capacity to detect ∼300K giant and sub-giant exoplanets opening a new window for studying the population of cool planets at large orbital distances at a few tens of AU. We will present the case of TWA 7b the lowest mass planet ever imaged, orbiting at 52 au. With a mass comparable to Saturn, we find evidence for a direct interaction with the debris disk, the planet being responsible of a Trojan belt.

Studying Massive Collisions in Exo-Kuiper Belts with Multi-Epoch Coronagraphy
Arin Avsar (University of Arizona)

The discovery of collisional remnants in recent years has shown that massive collisions may occur more frequently than previously thought. In addition, the aftermath of major planetesimal collisions offers us a unique opportunity to study the bulk properties of planetesimal belts. We present new, multi-epoch imaging of the Beta Pictoris debris disk in scattered light with HST/STIS. We present the highest precision, longest baseline surface brightness variation measurements from 1997 to 2023. Using a combination of surface brightness variation analysis and a collisional evolution models, we search for signs of recent collisional remnants and place constraints on the minimum mass collisional progenitor we are sensitive to with regular HST/STIS monitoring. Using this same multi-epoch analysis, we show the improvements JWST can offer in sensitivity to collisional remnants compared to HST. Furthermore, we present a modeling framework for simulating the rate and probability of massive collisions in young planetary systems. We show that the ongoing monitoring and discovery of collisional remnants can provide insightful information on planetesimal size distributions, planetesimal belt masses, and belt mean eccentricities, informing planetesimal formation models and the dynamical state of individual systems. We present current constraints achieved by applying this framework to the collisions discovered in the Fomalhaut and Beta Pictoris systems, in addition to guidance on future observing cadences for these targets with HST and JWST. Finally, we provide collision yield estimates for well-known, nearby debris disks with JWST and future observatories like Roman and HWO.

Formation Pathways of Nitrile- and Hydrocarbon-Based Organics in Titan's Atmosphere: Implications for Biosignatures and Origin of Life
Ashleigh Grace Hartwig (Florida International University)

With the arrival of the Cassini–Huygens mission to the Saturnian system in 2004, Titan entered a new era of exploration that transformed our understanding of planetary atmospheres and their potential links to prebiotic chemistry. Titan's atmosphere, dominated by molecular nitrogen (95-98%) and methane (2-5%), exhibits strong similarities to that of early Earth, making it a valuable analog for hazy exoplanets with reducing atmospheres. Using high-level electronic structure calculations at the CCSD(T)-F12/cc-pVTZ-F12//ωB97XD/6-311G(d,p) level of theory, we investigated the potential energy surfaces of the CH/C(^{3}P) + CH_3CN reactions to characterize plausible reaction pathways under Titan-like conditions. The reaction rates and branching ratios calculated via RRKM theory under single-collision (zero-pressure) conditions indicate that the CH + CH_3CN encounter predominantly yields CH_2CHCN + H and HCN + C_2H_3, while the C(^{3}P) + CH_3CN reaction is dominated by formation of 1-cyanovinyl (H_2CCCN). These pathways highlight efficient mechanisms for the conversion of simple hydrocarbons and nitriles into more complex prebiotic precursors, which could potentially lead to amino acids and nucleobases. These results explore the unique organic growth processes occurring on Titan with comparable ice giants and exoplanets, providing the chemical framework to interpret atmospheric and spectroscopic signatures observable with JWST and upcoming high-contrast imaging missions like the Roman Space Telescope.

NIRCam Bar Coronagraphy Reveals Enriched CO2 and Possible Planet-Like Formation for a Sample of Super Jupiters
Ashley Messier (Johns Hopkins University)

Linking substellar object composition to formation history is a major goal of high contrast imaging observations. Companions near the deuterium burning limit ($\sim$ 13 Mjup) are rare, and may form like planets (core accretion, "bottom up") or like stars/brown dwarfs (cloud collapse, "top down"). Objects formed from core accretion accrete metal-rich material from the circumstellar disk and exhibit enriched metallicity. By this logic, metallicity is one of the strongest formation tracers, but also one of the most difficult to unambiguously measure due to degeneracies between clouds and composition that inhibit accurate abundance measurements. Here, we summarize JWST cycle 4 NIRCam/LWBAR coronagraphy of a total of 6 companions with masses spanning the planet/brown dwarf boundary (4 - 18 Mjup) in the F410M, F430M, and F460M filters to directly probe the strength of CO2 absorption, a proxy for metallicity. Imaging a star positioned at the narrow end of the underutilized LWBAR mask results in higher throughput and a higher SNR detection for closer separation companions ($<$ 0.5") than with the more widely used round mask. The four HR 8799 planets (5-10 Mjup) exhibit stronger CO2 absorption than otherwise similar brown dwarfs, implying planet-like formation pathways. We detect 51 Eri b (2Mjup) at only 0.28" separation; the planet's 4-5 micron flux is consistent with strong vertical mixing and enhanced metallicity. We show that 29 Cyg b (15 Mjup) has a significantly enriched metallicity relative to its host, and agrees with the enhancement in the metallicities of super-Jupiters shown in the recently revised planetary mass/metallicity relation (Chachan+2025). Finally, we aim to present detailed atmospheric modeling of new observations of HR 2562 b (¡18 Mjup) and AF Leporis b (3.7 Mjup), which may reveal whether each object's composition is consistent with a brown dwarf or planetary formation history.

Coherent differential imaging on VLT/SPHERE : first results and beyond.
Axel Potier (Observatoire de Paris - LIRA)

High-contrast imaging relies on advanced coronagraphs and adaptive optics (AO) to suppress starlight. Yet, residual aberrations—particularly non-common path aberrations between the AO and coronagraph channels—still constrain instrument performance. Standard post-processing methods, such as angular differential imaging (ADI) or spectral differential imaging (SDI), can mitigate these effects to some extent, but they are prone to self-subtraction and lose efficiency at small angular separations or away from the star transit during the night. Coherent differential imaging (CDI) offers a promising alternative by calibrating static and quasi-static aberrations. Through speckle modulation, CDI isolates coherent starlight residuals, enabling their subtraction during post-processing. In this work, we validate a CDI method on real science targets observed with VLT/SPHERE, demonstrating its effectiveness in imaging nearly face-on circumstellar disks—objects typically difficult to recover with ADI. We also present further advancements, including parallelized multi-wavelength calibration using the SPHERE Integral Field Spectrograph and the mitigation of residual dynamic speckles through wavefront sensor (WFS) telemetry.

History Status Quo and Future of Observing Quasar Host Galaxies Using Coronagraphs
Bin Ren (Observatoire de la Cote d'Azur)

Over the past decade, advancements in high-contrast imaging have enabled the detection and characterization of over one hundred exoplanetary systems in stellar scales. However, in galactic scales, the light from galaxies have been overwhelmed by their central quasars, and they have been rarely explored using state-of-the-art coronagraphs. I will review the history of quasar host observations since the 1990s, demonstrate our recent efforts in applying coronagraphs (Hubble/STIS and VLT/SPHERE) to 3C 273 the original quasar which probed regions that are 8 times closer-in than prior studies, and discuss the future of quasar host imaging using upcoming and future coronagraphs in multiple wavelengths.

Accretion Light Echoes and Halpha Variability of a Protoplanet Candidate
Brendan Bowler (University of California, Santa Barbara)

Giant planets generate accretion luminosity as they form. Much of this energy is radiated in strong Halpha line emission, which has motivated direct imaging surveys at optical wavelengths to search for accreting protoplanets. However, compact disk structures can mimic accreting planets by scattering emission from the host star. I will describe an approach to distinguish accreting protoplanets from scattered-light disk features using "accretion light echoes." This method relies on variable Halpha emission from a stochastically accreting host star to search for a delayed brightness correlation with a candidate protoplanet. We apply this method to the candidate protoplanet AB Aur b with a dedicated Hubble Space Telescope Wide Field Camera 3 program designed to sequentially sample the host star and the candidate planet in Halpha while accounting for the light travel time delay of the source. AB Aur b is over 50 times more variable than its host star; we test whether the host and companion brightness changes are correlated, which would suggest scattering, or are unrelated, which may support the protoplanet hypothesis. More broadly, accretion light echoes offer a useful new tool to explore the nature of protoplanet candidates with well-timed observations of the host star prior to deep imaging in Halpha.

Prospects for Detecting and Characterizing the Atmospheres of White Dwarf Exoplanets
Caldon Whyte (Florida Institute of Technology)

White dwarfs offer a unique and promising opportunity for the detection of habitable exoplanets and their atmospheres. Due to a cooling effective temperature and compact size their evolving habitable zones exist mostly at orbital radii around 0.01 AU, close enough that a planet's orbit will quickly circularize and become tidally locked. Previous studies have provided many reasons for why white dwarfs are strong targets to explore the potential habitability of exoplanets. The period in their cooling during which the habitable zone is most stable ($\sim$7 Gyr) occurs when they have a similar effective temperature to the Sun, providing the proper energy to support photosynthesis and UV-driven abiogenesis, a process which potentially contributed to the origin of life. With comparable radial sizes between the white dwarf and an orbiting Earth-like planet, they provide good opportunities for detecting atmospheric signatures. However, it is necessary to better understand the climate dynamics of these planets to improve the outlook of confirming the detection of any signatures present. This work uses the Whole Atmosphere Climate Model (WACCM) to simulate the atmospheric evolution of an Earth-like planet orbiting in the habitable zone of a white dwarf with varying effective temperatures. The model is used to investigate how the synchronous rotation and modified received flux influence global circulation, and with coupled chemistry it will provide more insight into the chemical processes that impact an observed transmission spectra. These simulations are additionally used to generate synthetic spectra with NASA's Planetary Spectrum Generator to analyze the limits of detectable atmospheric signatures of a habitable planet and the potential to characterize such atmospheres. This work demonstrates the importance of linking atmospheric modelling with exoplanet detection. Further constraining the processes behind detectable atmospheric signatures with numerical modeling will further push the detection capabilities of current and next-generation observatories.

New substellar candidates identified with deep learning in the large-scale SHINE direct imaging survey
Carles Cantero (Observatoire de Geneve)

The SPHERE High-contrast Imaging survey for Exoplanets (SHINE, Chauvin et al. 2017; Chomez et al.2025) represents one of the largest and most sensitive direct imaging campaigns conducted to date, targeting over 400 young, nearby stars with the goal of detecting and characterizing giant exoplanets and brown dwarfs. This extensive dataset offers a unique opportunity to revisit observations using modern, data-driven approaches, potentially uncovering new substellar candidates that may have been overlooked by classical analysis techniques. In this context, our study focuses on reprocessing and reanalyzing the so-called F150 sample (Desidera et al. 2021; Langlois et al. 2021; Vigan et al. 2021), a well-defined subset of 150 main-sequence stars within 100 pc observed in the H-band with VLT/SPHERE as part of the SHINE survey. We employ NA-SODINN (Cantero et al. 2023), a supervised deep learning classifier designed to detect faint planetary signals in angular differential imaging (ADI; Marois et al. 2006) sequences, whose strong performance has been demonstrated by its top ranking in the Exoplanet Imaging Data Challenge (Cantalloube et al. 2020). For this analysis, we introduced two new modifications to the algorithm. First, since NA-SODINN produces confidence maps with uncalibrated probabilities rather than standard S/N maps, we implemented a principled detection rule based on an F1-score–driven thresholding strategy. This procedure provided an objective criterion for companion detection. Second, to compute detection limits, we adopted contrast curves based on 95% completeness instead of the classical 5σ criterion. With these advances, NA-SODINN recovers all known companions and several debris disks in the F150 sample, and reveals 13 new substellar candidates: ten detected in both H2 and H3 bands, and three in a single band. An initial color–magnitude analysis highlights three ambiguous cases and three promising candidates for follow-up.

Which Sonora Model Should I Use?

Caroline Morley (University of Texas at Austin)

Our greater modeling empire has provided a series of widely-used atmosphere and evolution models since 2020, starting with Sonora Bobcat (Marley et al. 2021), Sonora Cholla (Karalidi et al. 2021), Sonora Diamondback (Morley et al. 2024), and Sonora Elf Owl (Mukherjee et al. 2024). Upcoming releases include Red Diamondback (Davis et al.), Flame Skimmer and Gila Monster (Mang et al.). Here, I describe each modeling release, and offer guidance about when to use each. All models presented calculate the temperature structures, chemical abundances, and spectra of atmospheres assuming radiative-convective equilibrium.

Will Gaia DR4 Reveal New Targets for Roman/CGI

Charles Beichman (NASA Exoplanet Science Institute)

The Gaia DR4 release will identify planets orbiting stars not previously surveyed by other techniques. Although stars hotter than F5 cannot be surveyed using Radial Velocity techniques, we know from direct imaging of young stars, that such stars can host relatively massive planets. But little is known about the exoplanet population of mature F5-A0 stars. Gaia DR4 astrometry could find gas giants in few AU orbits around stars within a few tens of parsecs. The closest of these might be detectable using the Roman/CGI coronagraph. We will combine estimates of the Gaia's yield for nearby bright hot stars with CGI performance to assess which stars might also be suitable targets for Roman imaging.

Water ice in the debris disk around HD 181327

Chen Xie (Johns Hopkins University)

Debris disks are exoplanetary systems that contain planets, minor bodies (asteroids, Kuiper belt objects, comets and so on) and micrometre-sized debris dust. Because water ice is the most common frozen volatile, it plays an essential role in the formation of planets and minor bodies. Although water ice has been commonly found in Kuiper belt objects and comets in the Solar System, no definitive evidence for water ice in debris disks has been obtained to date. Here we report the discovery of water ice in the HD 181327 debris disk using the near-infrared spectrograph onboard the James Webb Space Telescope. We detected the solid-state broad absorption feature of water ice at 3 μm, including a distinct Fresnel peak at 3.1 μm, which is indicative of large, crystalline water-ice particles. Gradients in the water-ice feature as a function of stellocentric distance reveal a dynamic environment in which water ice is destroyed and replenished. We estimated the water-ice mass fractions as ranging from 0.1% at approximately 85 au to 21% at approximately 113 au, indicating the presence of a water-ice reservoir in the HD 181327 disk beyond the snow line. The icy bodies that release water ice in HD 181327 are probably the extrasolar counterparts of water-ice-rich Kuiper belt objects in our Solar System.

Improving High-Contrast Imaging Through Temporally Informed Post-Processing
Chia-Lin Ko (University of Arizona)

The direct imaging of exoplanets plays a crucial role in expanding our knowledge on exoplanetary system formation, atmospheric composition, and planetary system orbits. These observations require extreme contrasts on the order of 1e-5 to 1e-10, partially achieved through adaptive optics systems that stabilize incoming wavefronts and coronagraph masks that block bright host starlight. To reach the contrast needed for detecting exoplanets, additional post-processing of images is required to further suppress quasi-static speckle noise. While current post-processing algorithms such as Karhunen-Loève image projection (KLIP) achieve effective starlight subtraction by exploiting spatial or spectral diversity, they typically discard temporal correlations in the speckle field. In this work, we introduce a novel application of Slow Feature Analysis (SFA) to the problem of point spread function (PSF) subtraction. SFA is an unsupervised learning method that extracts slowly varying features from time series data. We adapt it to high-contrast imaging by identifying temporally invariant structures in reference images and using them to construct a stellar PSF model. We evaluate the performance of this approach on both ground-based observations of Beta Pictoris b from VLT/NACO and simulated datasets from the Roman Coronagraph Instrument observing scenario simulations. Our results demonstrate that SFA-based subtraction preserves exoplanet signals while mitigating quasi-static speckles, achieving signal-to-noise ratio improvements comparable with or exceeding KLIP in certain regimes. These findings highlight the potential of temporally informed algorithms as an alternative post-processing strategy that avoids common challenges of KLIP, such as over-subtraction and the need for forward modeling.

A New Method for Aperture Masking Interferometric Imaging: Demonstration with the JWST
Chris Carilli (NRAO)

We present a new method for aperture masking interferometric (AMI) imaging at near-IR wavelengths using radio astronomical techniques. Interferometric visibilities are derived from a Fourier transform of the interferograms. An iterative joint optimization process is then employed, using self-calibration of the interferometric element (hole in the mask) based complex voltage gains (i.e. electric fields), and CLEAN deconvolution to obtain the source structure. The technique was demonstrated in the optical laboratory at the ALBA synchrotron light source, where we recover the synchrotron light source structure and the aperture illumination pattern to 1% accuracy (Nikolic ea. 2024, PhysRev Acc & Beams, 27,1128). The phase gains were employed as a precise wavefront sensor, deriving wavefront path-lengths to each hole to sub-nm precision on millisecond timescales, thereby correcting for both static and time-variable phase fluctuations (Carilli ea. arXiv:2503.10820). We recently demonstrated the efficacy of the method using the AMI on the JWST at 4.8um and 3.8um (Carilli ea. 2025, SPIE Opt Eng submitted, arXiv:submit/6878635). Due to a number of effects at the JWST (the large pixel size, charge migration, near-field optics), the method requires an initial visibility-based amplitude normalization using observations of a point-source calibration star. We employ early science observations of the dusty binary Wolf-Rayet star WR137. Images with a dynamic range of 240 on the target, and 1000 on the calibrator, were synthesized from a short integration. The self-cal phase gains were used as a pseudo-real-time wavefront sensor, measuring the mirror segment pistons to a precision of order 20nm, likely limited by non-closing errors due to near-field optics issues. Including a baseline-based phase correction improves the dynamic range of the final images by about 23%. New results pushing the dynamic range and diffraction limit on JWST-AMI will be presented in Pasadena.

Pushing Coherent Differential Imaging to its Limits with SPIDERS
Christopher Mann (HAA-NRC)

The Subaru Pathfinder Instrument for Detecting Exoplanets and Recovering Spectra (SPIDERS) is an exploratory instrument testing new techniques and procedures for the next generation of exoplanet direct-imaging instrumentation. Here we discuss the Coherent Differential Imaging (CDI) post-processing technique as a way to substantially boost imaging contrast: including theoretical performance, real-world limitations due to chromatic fringe blurring, lab-bench performance, as well as first steps toward a machine learning algorithm to overcome certain limitations.

Extending the Capabilities of the Roman Coronagraph: Community Participation Program Hardware Working Development of Enhanced Modes and High Order Wavefront Sensing Simulations
Dan Sirbu (NASA Ames)

The Roman Coronagraph Instrument will be the first space instrument capable of directly imaging exoplanets in reflected light, opening a new observational window for exoplanetary systems. The coronograph instrument features ground-in-the-loop (GITL) operations intentionally designed to allow flexible adoption of new algorithms and observing strategies beyond its baseline capabilities. Through the Roman Community Participation Program (CPP), the broader community is assisting the coronagraph project to first achieve baseline functionality, develop a simulation and data processing pipeline. Beyond this the Hardware Working Group within the CPP is also engaged in extending functionality, exploring enhanced modes as demonstrators for the Habitable Worlds Observatory coronagraph instrument. The Hardware Working Group is advancing the development and readiness of enhanced coronagraph modes, with a focus on three "pipecleaner" modes that exercise the full hardware and operations pipeline. Current efforts focus on implementing (1) single-actuator alternate enhanced probes, (2) single-sided dark zones, and (3) single-polarization optimized control to assess performance gains and operational feasibility. In parallel, the group is building a simulation infrastructure that integrates the newly released coronagraph HOWFSC ground-in-the-loop (GITL) code with higher-fidelity preflight models, enabling robust performance validation and trade studies. These activities are supported by the creation of functional design descriptions (FDDs), mode prioritization exercises, and conops simulations to prepare compelling cases for early on-sky demonstrations. Collectively, this work is ensuring that both baseline and enhanced modes are technically mature, measurable in performance, and well positioned to inform future exoplanet imaging missions.

Characterizing Massive Planets and Brown Dwarfs with High-Contrast Imaging and Precision Astrometry
Danielle Bovie (University of Texas- San Antonio)

We present results for the SCExAO/CHARIS follow-up characterization of the directly-imaged superjovian exoplanets HIP 99770 b. SCExAO/CHARIS data provide high-contrast detections, astrometry, and 1.1–2.4 micron spectra of the faint companion. HIP 99770 b was originally detected in the low resolution (R$\sim$20) broadband mode, while this follow-up revisited the planet in higher resolution H and K-bands (R$\sim$80). These new observations allow us to put further constraints on the planet's atmosphere, orbit, and dynamical mass.

REDWOODS: a Platform at Lick/ShaneAO for Testing Second Stage AO Technologies
Dominic Francisco Sanchez (Lawrence Livermore National Laboratory)

High contrast exoplanet imaging and adaptive optics (AO) technology development is a key priority set forth by the 2020 Decadal Survey of Astronomy and Astrophysics to bridge the 100x contrast gap needed for near infrared habitable exoplanet imaging with future Extremely Large Telescopes. REDWOODS—Real time Exoplanet Direct imaging via Wavefront control Of Optical DefectS—is a collaboration between Livermore National Laboratory (LLNL) and University of California Santa Cruz (UCSC) designed to test AO technologies to bridge this gap with upgrades to the Shane AO system at Lick Observatory. The project implements a self-coherent camera, with an optional 20% spectral bandwidth Wynne corrector mode, and 50% spectral bandwidth 3 sided Pyramid wavefront sensor as near infrared second stage AO systems without their own deformable mirrors (DMs), instead implementing new real-time multi-wavefront sensor (WFS) control software to interface with the existing ShaneAO Shack Hartmann WFS to control ShaneAO's existing woofer tweeter DMs. In addition to an overview of the instrument we summarize (1) the optical and mechanical design of the periscope bench and it's components, including a vibration analysis from ShaneAO accelerometer measurements showing sufficient stability for REDWOODS, (2) multi-WFS software design and ongoing testing and development efforts, and (3) UCSC integrating and testing results and ongoing testing efforts at Shane. The project is currently undergoing commissioning at the telescope, with on-sky testing expected to start in early 2026. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. This document number is LLNL-ABS-2004880.

The Disk Connection: Detecting Planets Around Disk-Hosting Stars with Hipparcos and Gaia Astrometry

Dori Blakely (University of Victoria)

Connecting observed planets with known structures seen in circumstellar disks is necessary in order to constrain the formation pathway, evolution and migration of planetary systems. However, relatively few planets have been detected around young stars hosting prominent circumstellar disks, despite thousands of hours of telescope time spent searching with direct imaging and radial velocity surveys. Furthermore, of these known planets, very few appear to be directly responsible for the observed disk substructures. In this talk, I present several newly detected planetary mass companion candidates around disk-hosting stars, utilizing a novel combination of astrometry from Hipparcos and Gaia. I show how using this combination of data we can not only clearly detect the presence of planets, but also predict their positions, allowing for follow-up with instruments such as VLTI/GRAVITY. For several additional systems with known disk sub-structures, I present robust companion mass limits which can be used to constrain the origin of the disk features. Finally, I discuss how these results compare to what can be expected with the upcoming release of epoch astrometry in Gaia DR4 and the special care that will be necessary for analyzing Gaia DR4 data of disk-hosting stars.

New multi-epoch H-alpha monitoring observations of PDS 70 b and c

Dorian Demars (University of Virginia)

Giant planets acquire their mass by gas accretion directly from their natal circumstellar disk and/or through their circumplanetary disk. This mechanism is usually studied through accretion lines (e.g., Halpha), as they are tracers of the accretion shock and surrounding heated region. Even though emission lines are known to be variable, studies have so far often focused on snapshot observations, when multi-epoch observations give direct insights into the accretion and dynamics variability. Since their discovery and confirmation through their Halpha line, PDS 70 b & c have been the main laboratory for studying planet-disk interaction and accretion processes in young forming systems. While high-amplitude Halpha variability has been observed over year-long timescales, it is likely tracing the general accretion flow variations, and intrinsically misses short variations that may occur at the planet-CPD interface. We present the results of an HST narrow-band imaging program of the Halpha line of both PDS 70 b & c planets. We probe 5 independent epochs, and the associated Halpha variability for timescales of days, a month, and a year. This also includes an 11-hour-long epoch, providing for the first time the opportunity to probe variability on the rotation period timescale. We derive constraints for line and accretion rate variability and discuss our findings in the context of different accretion scenarios. Finally, we discuss the implications for detection from Halpha imaging campaigns.

Following Up Alpha Cen Ab Planet Candidate using the Roman Space Telescope Coronagraph

Eduardo Bendek (NASA Ames Research Center)

The Roman Space Telescope Coronagraph offers a unique opportunity to observe our nearest solar twin, Alpha Centauri A, and characterize the habitable zone gas giant candidate Alpha Cen Ab. The candidate uniquely stands out among all imaged exoplanets to date as the one most similar in temperature and age to the planets in our own Solar System. Roman CGI offers the tantalizing opportunity to independently confirm the candidate, determine its radius, temperature, and albedo, and constrain its orbit. Confirmation of Alpha Cen Ab by Roman would make it the first exoplanet to be imaged in both thermal emission and reflected light and motivate launching an exciting search for habitable exomoons (similar to the Pandora-Polyphemus system in Avatar) with the upcoming ELTs and HWO. In addition, this candidate will inform the planet formation history and current

dynamics of the Alpha Centauri AB system, including potentially habitable planets around both stars. In this talk we describe our plan to observe this target using the Roman CGI as well as describe the key technical insights about the coronagraph performance that we aim to learn, such as measuring companion leakage intensity, evaluating the impact of large stellar diameter, and assessing CGI performance on very bright targets. In subsequent observations we aim to demonstrate Multi-Star Wavefront Control (MSWC) on sky observing Alpha Cen A using the Wide FoV Shaped Pupil MSWC contributed mode in the Roman CGI. The insights from these technology demonstrations are crucial preparation for the planned HWO mission.

Multi-Bandpass Exoplanet Atmosphere Reconnaissance (MPEAR): Optimizing HWO's First-Visit Photometric Strategy
Eleonora Alei (NASA GSFC (NPP Fellow))

As the architecture for the Habitable Worlds Observatory (HWO) is being developed, it is crucial to optimize observing strategies for efficient target identification and characterization of Earth-like planets around Sun-like stars. Current HWO concepts enable simultaneous multi-bandpass observations with the coronagraph instrument, critical for performing qualitative planetary reconnaissance to optimize observing time and prioritize characterization of promising targets. In this contribution, I will present the Multi-Bandpass Exoplanet Atmosphere Reconnaissance (MPEAR) algorithm, designed to determine the optimal combination of broadband photometric observations for extracting maximum information from the first visit. MPEAR identifies degeneracies in orbital configurations, fluxes, and noise properties, then determines optimal secondary photometry bands to resolve these ambiguities and to efficiently use telescope resources. I will describe the results of a recent publication, where we have applied the MPEAR methodology comparing an Earth seen at quadrature with cold and warm Neptune analogs at inclined orbits and varying phases, with comparable flux in a discovery bandpass centered at 500 nm (20% bandwidth). Using pyEDITH, the official noise and exposure time calculator for the HWO coronagraph instrument, we evaluated the differentiation potential across various observing scenarios. Our analysis reveals that the baseline S/N=7 (3.2 hours observing time for a planet at 10 pc) using two parallel bandpasses (550 nm + 850 nm) only marginally differentiates Earth from cold Neptune-like planets. However, increasing to S/N=15 (7 hours) with three parallel bandpasses (300 nm + 500 nm + 1.11 μm) distinguishes Earth from both warm and cold Neptune scenarios. This methodology is directly adaptable to evolving Exploratory Analytic Cases (EACs) in HWO architecture trade studies, providing crucial input for mission design optimization.

ESCAPE: investigating active observing and post-processing methods for Roman and HWO
Elodie Choquet (LAM)

The search for biosignatures in potentially habitable exoplanets is one of the major astrophysics' drivers for the coming decades and the prime science case of the Habitable World Observatory (HWO). To this goal, HWO must achieve 1e-10 contrast levels in visible light within a few resolution elements of the star. This requires developing and maturing new technologies (DMs, coronagraphs, wavefront sensing & control methods...), and optimizing them together with a system approach to relax the most stringent constraints with the assets of each sub-system. Observing strategies and data post-processing for instance have a lever arm on the picometer stability requirement on the observatory and should be investigated and integrated in the system-level optimization as well. In particular, the presence of wavefront sensors and deformable mirrors in the system open new prospects to calibrate and subtract the residual starlight at post-processing, compared to passive JWST and HST. The ESCAPE project aims at investigating such methods and demonstrating them on the Roman Coronagraph instrument. Building the tip-tilt small grid dithering method on JWST, which methodically samples the impact of pointing errors during the reference star visits to improve the target starlight subtraction at post-processing, we propose the high-order dithering method, an extension of this strategy to higher orders by use of the deformable mirrors. In this presentation, we present the current development of this method through numerical simulations, demonstration on the HiCAT testbed, and prospects for an on-sky demonstration on the Roman Coronagraph in a possible extended mission.

Intrinsic polarization aberrations in black silicon shaped pupil Lyot coronagraphs
Emory Jenkins (University of Arizona)

The Habitable Worlds Observatory (HWO) will have a segmented primary mirror, resulting in diffraction artifacts that increase coronagraphic leakage. Shaped pupil Lyot coronagraphs are effective at mitigating this by blocking the regions of the pupil that contribute the most leakage and passing the rest. Black silicon shaped pupil masks (SPM), made by cryo-etching aluminum-coated superpolished silicon wafers to create highly absorptive black regions, are under development by JPL to reach the 1e-10 contrast requirement of the HWO coronagraph instruments. At this contrast, the anisotropic interactions of EM waves with the small features of the SPM and occulting focal plane mask (FPM) generate polarization aberrations that contribute to leakage. Using finite-difference time-domain (FDTD) simulations in Meep, we model the response of individual aluminized, perfectly square pixels in the context of adjacent aluminized or black pixels. From these responses, we construct the Jones matrices of 1e-10 contrast SPM designs for the HWO. We also generate the Jones matrix of the FPM using FDTD, and use a physical optics model in HCIPy to estimate the leakage associated with their polarization aberrations.

Direct Measurement of Extinction in a Planet-Hosting Gap
Gabriele Cugno (University of Zurich)

Recent disk observations have revealed multiple indirect signatures of forming gas giant planets, but high-contrast imaging has rarely confirmed the presence of the suspected perturbers. One possible explanation is that extinction from circumstellar material obscures their emission at near-IR wavelengths, but a direct measurement of the extinction properties of disks has remained beyond reach. In this talk, we present our analysis of the background star AS 209bkg, which shines through a wide annular gap in the AS 209 disk where a protoplanet is suspected to be forming. We perform transmission spectrophotometry combining new VLT/SPHERE and JWST/NIRCam observations with archival HST data from 2005. We model the spectral energy distribution (SED) of AS 209bkg over a 19-year baseline and directly measure the extinction from gap material for the first time. We find that circumstellar disk extinction does not follow the same behavior as the ISM, with significant implications for future searches for protoplanets and observing strategies. Our results reveal that even wide, deep gaps can significantly obscure emission from protoplanets, including those following a hot-start evolutionary model. Our extinction measurements help reconcile the discrepancy between ALMA-based predictions of planet-disk interactions and the non-detections from sensitive optical and near-infrared imaging campaigns.

JWST/NIRCam imaging of the HR 8799 planetary system
Geoffrey Bryden (JPL)

We observed the HR 8799 planetary system with JWST's NIRCam instrument using its F356W and F444W filters to search for additional, lower-mass planets that might reside between or exterior to the four previously detected Jovian-mass planets. After blocking out the star with a circular occulting mask with gradual radial opacity, the four known planets (b, c, d, and e) are detected in both filters, even though the innermost planet lies so close to its parent star that the coronagraphic mask nominally blocks 86% of the planet's light. The observed fluxes and positions of the planets are consistent with previous models of the planets' atmospheres and with predictions of orbital fits. Two background sources are detected interior to and within the outer debris ring, respectively, both of which are visible in ALMA images at sub-mm wavelengths. No new planet candidates >1 MJup are seen within the region defined by the 4 known planets. Planets larger than a Saturn mass (0.3 MJup) are ruled out within the outer gap between HR 8799 b (at 70 AU) and the cold belt of debris (>120 AU), limiting the ability of a potential planet in that region to sculpt the inner edge of the outer disk.

The Past Present and Future of Coronagraphy with NASA Missions
Hannah Jang-Condell (NASA Headquarters)

NASA has been a long-standing investor in high-contrast imaging. Flagship missions including

Hubble, JWST, Roman, and HWO have or will have a coronagraph. NASA also supports technology development for high contrast imaging in the lab, on ground-based facilities, and on sub-orbital missions. In this talk, I will give a brief overview of high contrast imaging from space with NASA missions and the technology development that has gone with it.

Coronagraph as a Low-Resolution Spectrometer
He Sun (Peking University)

Spectroscopic characterization is crucial for understanding stellar properties and for accurately calibrating the spectral differences between reference and target stars, which is essential for precise Point Spread Function (PSF) subtraction. However, many telescopes are not equipped with dedicated spectrographs for such characterization. In this presentation, we propose that a coronagraph can inherently function as a low-resolution spectrometer. Spectral variations induce changes in the broadband PSF. Coronagraphs, due to their modulation of the PSF, can amplify the impact of these spectral differences. By formulating a computational imaging problem that fits the spectrum to the observed PSF, we demonstrate that it is possible to reconstruct the spectral information of a target from a single broadband coronagraphic image. We validate the feasibility of this concept using both simulated and experimental data. We also demonstrate its application to exiting coronagraphs (HST/STIS, JWST/NIRCam), and discuss its capability in relaxing the color match requirement of PSF stars for future telescopes.

Enhanced Wavefront Sensing for Roman CGI: Single-Actuator Probes with Flight-Like Validation
Iva Laginja (NOVA/Paris Observatory)

The Coronagraph Instrument (CGI) aboard the Nancy Grace Roman Space Telescope will be the first space-based platform to implement closed-loop focal-plane wavefront sensing and control (WFS&C), providing a critical technology demonstration for the Habitable Worlds Observatory (HWO). The baseline mode employs the narrow-field of view Hybrid Lyot Coronagraph, using pair-wise probing for electric field estimation and electric field conjugation for correction. While this defines nominal performance, "enhanced modes" are being developed to extend Roman's efficiency and science reach. A key potential enhancement is the use of single-actuator probes for electric field estimation. Unlike baseline sinc-function probes, single-actuator probes operate in an extended linear regime, allowing stronger amplitudes without violating estimator assumptions. This increases the signal-to-noise ratio of probed images, reduces exposure times, accelerates dark-hole convergence, and improves robustness to DM effects. Critically, high-amplitude probes could extend WFS&C operation to stars fainter than the current $V < 3$ reference limit, enabling dark-hole creation directly on science targets down to the $V < 5$ threshold set by the low-order wavefront sensor. To validate these enhancements, the Coronagraph Community Participation Program's (CPP) Hardware Working Group is investigating their feasibility, and modeling potential performance gains in Roman's operational environment. Dark-hole loops are executed with cgi-howfsc, the operational high-order WFS&C software, coupled to CorgiSim, which incorporates the official CGI PROPER optical model. This provides end-to-end, flight-like validation of enhanced observing modes and quantifies their impact on Roman Coronagraph performance. We present results from these simulations, showing how single-actuator probes may shorten exposure times, accelerate convergence, and remain robust against DM nonlinearities such as hysteresis and neighbor effects. The goal is to operate single-actuator probes as a low-risk, high-gain enhancement for Roman CGI, increasing efficiency, expanding the accessible target list, and validating WFS&C strategies essential for HWO.

A Novel Autodiff Pipeline for Freeform Forward Modeling of Circumstellar Disks
Jay K Kueny (The University of Arizona)

Modeling circumstellar disks in the traditional sense carries the assumption that the dust density distribution follows a fixed parametric form. Furthermore, the algorithms most-commonly used for subtracting the stellar point-spread function (PSF) distort the true morphology of the faint underlying disk structure, especially dusty features that are located at small angular separations. Thus, modeling with parametric disk models often leads to significant residuals and makes it difficult to measure the full realizable range of the scattering function of the dust. We introduce our efforts towards solving these problems with a novel, pixel-based freeform forward modeling pipeline for characterizing extended objects using images reduced with the KLIP algorithm. We built this pipeline within the framework of JAX, which is a machine learning library in Python that enables efficient optimization through automatic differentiation (”autodiff”) and GPU-accelerated array computations. Using on-sky visible light images of the disk around HR 4796 taken by the ”extreme” Magellan Adaptive Optics instrument (MagAO-X), we demonstrate that our data-driven freeform models excel at fitting a complex dust distribution and can infer the dust scattering properties even through PSF subtraction artifacts. Since our pipeline outputs the deconvolved reconstruction of the disk, we will discuss the implications of retrieving morphological features finer than a resolution element. Finally, we will explain our plans to better characterize noise features in MagAO-X images such as the wind-driven halo to prevent our models from learning these nuisances and biasing the photometry.

Quantifying The Information Content In High Contrast Imaging Data
Jayke Samson Nguyen (University of California, San Diego)

A standing problem in high contrast imaging when considering PSF subtraction for exoplanet recovery is the trade off between noise suppression and the self-subtraction of the planet signal. Current methods maximize the signal-to-noise ratio by trying to minimize the noise, but this approach can often lead to significant self-subtraction. While the signal-to-noise ratio is an important quantity that determines our precision, it is secondary to our measurements of the photometry and astrometry of the target, which are our actual science drivers. Thus our true goal should not be to improve the signal-to-noise, but instead try to reduce the uncertainty in our measurements. The Fisher information gives us a way to measure the information content of a given observable that is sampled from an arbitrary probability distribution. This allows us to measure the contribution of each data point to the overall precision of the final measurement. The Fisher information can then be used to optimize PSF subtraction techniques to minimize the uncertainty of our desired observable, such as the photometry or astrometry of a planet signal. This information-based technique can also be utilized during the observing phase to optimize the number of data points used, and therefore the observing time spent on a target. In short, we provide an alternative information-theoretic metric using the Fisher information to optimize observing and post-processing techniques, improving our overall science return.

Using Astrometry and RV to Identify New Exoplanets and Brown Dwarfs Amenable to High-Contrast Imaging From the Ground and Space
Jie Li (The University of Texas at San Antonio)

Jointly analyzing radial-velocity data drawn from multiple instruments and precision astrometry helps to better constrain dynamical masses and orbits of jovian planets and brown dwarfs. By cross-matching the Hipparcos Gaia Catalogue of Accelerations (HGCA) with RV data, we have identified a sample of accelerating stars with RV trends with a wide range of estimated ages. Using the orbit fitting code orvara to jointly model these RV data and precision astrometry from the HGCA, we confirm at least two systems with newly-discovered massive exoplanets and brown dwarf companions. We assess the detectability of these companions with current ground-based extreme AO platforms, JWST, and Roman to confirm and characterize the nature of the companions.

CorgiSim: A Community Tool for Roman Coronagraph Simulations
Jingwen Zhang (University of California, Santa Barbara)

NASA’s Roman Space Telescope will feature a pathfinder coronagraph to demonstrate high-contrast imaging from space, paving the way for future missions like the Habitable Worlds Observatory. If the technology demo is successful, Roman-CGI could obtain spectroscopy of Jupiter analogs in reflected visible light for the first time. In this poster, we present the work of developing an open-source simulation package “CorgiSim” as part of the Roman Coronagraph Community Participate Program. Built on established optical propagation libraries such as PROPER and CGISim, CorgiSim provides a user-friendly, publicly available Python framework for end-to-end simulations of all Roman-CGI observing modes. The package produces high-fidelity, format-compliant data for pre-launch calibration, pipeline testing, and community applications such as target planning and selection. We will give an overview of CorgiSim's infrastructure, functionalities, and current implementation across planned imaging, polarimetry, and spectroscopy modes, including the ability to simulate host stars, injected companions, and extended disks. We will also highlight suitable applications of CorgiSim and provide guidance on how users can access and employ the software.

Cold Planets Around White Dwarfs with JWST
John Debes (STScI)

The sensitivity and spatial resolution of JWST in the near and mid-IR has opened the door to very detailed studies of white dwarf planetary systems. I will review the results of the MIRI Excesses Around Degenerates (MEAD) Cycle 2 survey that targeted 56 white dwarfs within 25pc. I also show follow-up observations with Keck/HIRES and Gaia astrometry that hint at a potentially large population of cold giant planets with orbital separations <10 au around former A and F type stars. These results can provide context to future planetary system demographic information that will come from astrometric results with Gaia DR4 and microlensing results with the Nancy Grace Roman Telescope. This work also helps to determine the fate of giant planets at orbital separations much like our own Solar System.

Optimizing the detection of exoplanets with JWST/MIRI: comparing direct imaging and coronagraphy
Jonas Wehrung-Montpezat (Paris-Meudon Observatory)

The detection of TWA7b with the MIRI coronagraph, the first exoplanet discovered by JWST and the lowest mass planet ever imaged (Lagrange et al. 2025), has demonstrated the unique ability of the telescope to detect cold exoplanets at large separation in the mid-infrared. However, this major result, as well as the detection of eps Ind Ab (Matthews et al. 2024), raises the question of which mode of JWST/MIRI, coronagraphy or direct imaging, is most relevant for the detection of exoplanets, depending on separation and flux ratio. We conducted a systematic analysis comparing the different modes and filters of JWST/MIRI, combining realistic simulations and JWST archival data. Coronagraphic observations were simulated with PanCAKE (Carter et al. 2021), an extension of the Pandeia software for coronagraphy, integrating realistic optical path difference maps, and imaging observations with Pandeia and MIRISim. For each simulation, we derived contrast curves and extracted flux detection limits. These simulations, often too optimistic when used with reference differential imaging, were complemented by an analysis of archival JWST data. Mass detection limits were then derived with the evolutionary and atmospheric model HADES, developed at the Observatoire de Paris, allowing us to compare the performance of observing modes across different wavelengths. This combined approach enables a direct comparison between imaging and coronagraphy for exoplanet observations. We will present our method to predict detection performance in any stellar system or exposure time, by extrapolating contrast profiles from existing JWST observations. We will also show mass detection limit curves for coronagraphy and imaging, based on both simulations and archival data, and discuss the advantages and limitations of each observing strategy.

Development of a hybrid physical optics and deep learning model for speckle evolution
Joseph Long (Flatiron Institute / CCA)

Current-generation ground-based telescopes image the habitable zone of our nearest stellar neighbors at a very small angular separation from the host star. At these separations, high-contrast observations are challenging due to correlated non-stationary noise from starlight (i.e. speckles) and a lack of angular diversity due to the smaller arc a notional close-in source makes as the sky rotates through transit. Debris disks and other extended structures subtend larger angles, but pose a similar challenge as astrophysical signals of interest can leak into PCA-based models of focal plane intensity. Using a combination of a physics-based flexible point-spread function (PSF) model and machine learning techniques, we are developing a technique to capture correlations between wavefront measurements and time-evolving speckles in the MagAO-X focal plane. By implementing a fully differentiable physical optical simulation in the JAX machine learning framework we have created a model that couples a neural network "encoder" with a physically realistic "decoder". When the gradient of the decoder stage alone is used to optimize amplitude and OPD functions, this model works to perform phase retrieval of non-common-path (NCP) errors. The machine learning model then learns to produce only the difference from the "flat" state that produces a given focal plane PSF, layered on top of the NCP aberrations. A single MagAO-X observation may result in multiple terabytes of wavefront and focal plane data, making this a challenging data engineering problem as well. We will also discuss our experiments with the temporal compressibility of closed-loop wavefront sensor data.

Ground/space complementarity in the direct imaging of exoplanetary systems, a review
Julien H Girard (STScI)

The detection and characterization of substellar companions and exoplanets around nearby stars by means direct imaging is now an established field. It motivates this series of Spirit of Lyot conferences every few years and it is a driving science case of future giant telescopes on the ground and in space. Both present advantages and drawbacks and both are outstandingly pertinent despite their limitations. Space offers spectral coverage and unparalleled stability and sensitivity, a path forward to studying a number of Earth twins in reflected light in the coming decades. Adaptive optics in all its flavors combined with coronagraphy and/or interferometry high has really transformed giant telescopes on the ground into compelling exoplanet imagers with a clear advantage towards angular resolution, easier instrument servicing and multiplexing. In this review, my aim is not to oppose ground-based facilities to space missions. Rather, I am emphasizing on their complementarity and the absolute necessity of developing identifying synergies, gaps and bridges in exoplanet research and technologies. As a community we need to understand the whole picture of planet formation, improve demographics, detect more mature exoplanets both in thermal emission and reflected light, study their atmospheres, their migration mechanisms, etc. It is fundamental to have a holistic view on how to best design and use our facilities, how to inform our surveys with cross-technique approaches (astrometry, radial velocities), how to cross-calibrate and trust our measurements across time, and how to push standards of post-processing. It is an exciting time to work in this field, the future is bright to study faint blobs!

The First Saturn Analog: Exploration of the TWA 7 Planet–Disk System with JWST NIRCam
Katie Crotts (Space Telescope Science Institute)

The young M-star TWA 7 hosts a bright and near face-on debris disk, imaged over several decades. The disk displays multiple complex substructures such as three disk components and spiral arms, suggesting the presence of planets to actively sculpt these features. The evidence for planets in this disk was further strengthened with the recent detection of a point-source compatible with a Saturn-mass planet companion using JWST/MIRI. This detection is significant, as the candidate would be the smallest planet ever to be directly-imaged and is also at the same location a planet was predicted to reside based on the disk morphology. Here, we present observations of the TWA 7 system with JWST/NIRCam in the F200W and F444W filters. In the F444W, we are able to detect faint emission coinciding with the location of the planet candidate imaged with MIRI. Measurements of the candidate's flux with NIRCam further support the candidate as a sub-Jupiter mass planet companion. Therefore, TWA 7 provides a rare opportunity to directly study planet-disk interactions and characterize a young, Saturn analog for the first time.

Development of High-Contrast Imaging Techniques for Direct Observation of Exoplanets in Binary-Star Systems
Kenta Yoneta (Tokyo University of Agriculture and Technology)

Not only single-star systems but also multiple-star systems are interesting observational targets for exoplanet exploration. For direct observation of exoplanets in multiple-star systems, high-contrast imaging techniques are required that can simultaneously suppress light from these stars. Therefore, we have been developing high-contrast imaging techniques aimed at the direct observation of exoplanets in binary-star systems. For example, we have proposed applying a common-path visible nulling coronagraph (CP-VNC), originally proposed for single stars, as a coronagraph for binary stars. The CP-VNC consists of a polarization beam splitter based on a birefringent prism and two polarizers. Laboratory demonstrations have shown that the CP-VNC can simultaneously suppress the diffraction light from celestial objects aligned in a single line on the observation plane. Furthermore, we have been conducting numerical simulations of binary-star system observations using a focal plane phase mask coronagraph, such as the eight-octant phase mask (8OPM) coronagraph. Additionally, we have been developing wavefront sensing and control techniques to suppress the scattered light (speckles) from binary stars. In our laboratory demonstration of wavefront control technique, a spatial light modulator has been applied that can suppress speckles at positions distant from the star, thanks to the large number of control elements. We also extended the speckle area nulling (SAN) method, originally proposed for single-star systems, to binary-star systems as a wavefront sensing and control algorithm. Currently, we are developing a technique that can efficiently measure wavefronts with fewer focal plane intensity measurements.

JWST/MIRI Coronagraphy of the Benchmark Brown Dwarf Companion GJ 758 B
Kimberly Ward-Duong (Smith College)

The coldest substellar companions to Sun-like stars represent a rare and important population for comparison with our Solar System, yet no true Jovian analogs (1 Jupiter mass, 5 au orbit) have been atmospherically characterized to date. Evolutionary models predict that Jupiter would have been in the T-dwarf temperature range (500 K) during its first few million years, making T-dwarf companions key comparisons to our own planetary system's early history. Although over 900 T-dwarfs are known, only six have been identified as companions to stars on Solar-System-sized scales ($<$ 40 au). The best studied of these is GJ 758 B, owing to its 15 pc proximity, Hipparcos-Gaia proper motion acceleration, and extensive ground-based monitoring, with observations spanning over 20 years of radial velocity measurements and over 10 years of direct imaging. Here we present the first mid-infrared images of this benchmark companion, obtained with JWST/MIRI coronagraphy using the four quadrant phase masks covering 10.65 μm, 11.40 μm, and 15.50 μm. We highlight intriguing differences in color-magnitude space when comparing near-IR and mid-IR properties of the T-dwarf population, with objects identical to GJ 758 B in the near-IR exhibiting substantially different mid-IR colors. Combined with this system's wealth of previous measurements, the new JWST coronagraphy enables an astrometric constraint on the mass of the companion to unprecedented precision (36.8 $\pm$ 0.5 Jupiter masses) and a detailed atmospheric characterization, with the range of model fits underscoring the importance of disequilibrium chemistry, composition, and vertical mixing in the 500-600 K temperature regime. Finally, we discuss candidate companions in our deep MIRI images and new methods to discriminate contaminant galaxies from substellar sources in the mid-IR.

A Deep HST/WFC3/H-alpha Imaging Survey to Probe the Demographics of Accreting Planets at Wide Separations
Lillian Yushu Jiang (UCSB)

Traditional direct imaging surveys of exoplanets are limited by their reliance on thermal emission, potentially biasing our understanding of exoplanet demographics at wide separations. Hot-start planets, with higher luminosities during formation, are favored over cold-start giants, which are fainter and harder to detect. Sub-Jovian-mass planets at wide separations also remain largely unexplored. Hα emission from accreting planets offers an alternative method to estimate occurrence rates regardless of thermal evolution and, with sufficient sensitivity, enables searches for lower-mass planets. We present results from a deep HST/WFC3-UVIS Hα imaging survey of over 200 members in the $\sim$2 Myr-old IC 348 region. Using a deep learning-based image classification model to separate real sources from cosmic-ray-induced false positives, we identify one new brown dwarf companion candidate and provide upper limits on Hα luminosities, accretion luminosities, and mass accretion rates for non-detections. Ultimately this study provides the most precise demographic constraints on an otherwise hidden population of long-period accreting protoplanets.

High-Order Modes Dithering for the Roman HLC: Results with the CAPyBARA Simulator
Lisa Altinier (laboratoire d'Astrophysique de Marseille)

The Hybrid Lyot Coronagraph (HLC) of the Roman Space Telescope will serve as a crucial testbed for high-contrast imaging with space-based deformable mirrors (DMs), enabling the detection and characterization of exoplanets in reflected light. While standard post-processing methods are expected to reach contrasts down to 1e-9, they are not optimized for space-based DMs. To address this, we aim to test a new technique, High-Order Modes Dithering (HOMD), by injecting calibration maps directly onto the DMs and increase the diversity in the PSF library used for the post-processing. To explore this approach, we built our own simulator, CAPyBARA (Coronagraph and Aberration Python Based Algorithm for Roman Analysis), which allows us to tune both the quasi-static aberrations and the HOMD maps. We systematically injected HOMD using Zernike modes from Z5 to Z24, finding that lower-order modes provide larger improvements than higher-order modes. Using CAPyBARA, we compare post-processing results obtained with classical RDI (cRDI), classical KLIP, and KLIP combined with HOMD. The dark hole (DH) extends from 3 to 9 λ/D, with the most significant improvements observed in the inner annulus between 3 and 6 λ/D. We also explored different aberration drifts between the reference and science stars, finding that the best performance with HOMD occurs for a 10% drift (corresponding to the regime used for OS11) where the reference star's aberrations evolve at 10% of the speed of the science star. Depending on the HOMD maps and aberration regime, we observe contrast improvements up to a factor of $\sim$x50 in the inner DH.

Restoring the lost performance of JWST's Aperture Masking Interferometer with AMIGO
Louis Desdoigts (Leiden University)

The James Webb Space Telescope (JWST) has provided a stable and precise space-based observatory in the optical and infrared, enabling the next generation of exoplanetary science with observations at deeper contrasts and smaller angles than previously accessible. However, its stability has also revealed non-linear detector systematics that limit the precision required for exoplanet studies. JWST also includes the first science-focused space-based interferometer: the Aperture Masking Interferometer (AMI). In theory, AMI is far more capable than any contemporary system at comparable wavelengths. The interferometric calibration techniques that enable the resolution of structure inwards of the diffraction limit, however, assume a linear detector response - a property strictly violated by the nonlinear migration of charge between pixels known as the Brighter-Fatter Effect (BFE) and found within JWST's detectors. As a result, despite years of communal effort, classical pipelines have fallen an order of magnitude short of AMI's expected performance. In this talk I present AMIGO: A data-driven end-to-end differentiable forwards modelling pipeline that restores the lost performance of JWST's only interferometric imaging mode. Operating directly on raw data, AMIGO combines a high-fidelity physical optical model, the development of forwards-modelled interferometric signals, generalisations of self-calibration techniques, a hybrid forwards- and machine-learned model of the non-linear detector dynamics, as well as a calibration of the residual electronic signals imprinted into each image. Calibrated entirely from on-sky data, it recovers companions up to 9 magnitudes at 100 mas, previously lost beneath the systematics.This re-commissioning of AMI restores its lost performance and re-centers AMI as a viable observational mode on JWST.

Simulated parametric study of coherent differential imaging for exoplanet detection with SPHERE(+).
Lukas Delaye (LIRA, Paris-Meudon Observatory)

Exoplanet imaging directly detects light reflected, transmitted, or emitted by a substellar object. However, optical aberrations limit the detection threshold of such faint objects. In this presentation, I study an innovative method called coherent differential imaging (CDI). This technique is based on the temporal modulation of optical aberrations using an algorithm known as Pair-Wise Probing. Here, this technique is studied with realistic simulated settings of the VLT/SPHERE and SPHERE+ instruments, using the end-to-end adaptive optics AO simulation tool COMPASS. Several physical and instrumental parameters are explored, such as the time spent calibrating the residuals, the amplitude of the modulations, the wind speed in the atmosphere and the magnitude of the target star. The parametric analysis highlights optimal correction regimes, as well as the limitations introduced by the algorithm's non-linear effects and extreme atmospheric conditions. This work paves the way for future integration of the CDI method as part of the SPHERE+ project, and more broadly in next-generation direct imaging instruments, both on the ground and in space e.g. with the future Roman Space Telescope.

CorGI-REx: Reference Star Vetting for the Roman Coronagraph Instrument with High-Contrast Imaging from VLT/SPHERE
Macarena Constanza Vega Pallauta (Max-Planck Institute for Astronomy)

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 (CGI) 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 17 previously unreported companions around 4 stars that are not listed in Gaia DR3, and we perform photometric and astrometric characterization to confirm whether they are bound or background objects. From the ensemble of observations, we derive median detection limits of Δmag $\sim$ 14 at 0.5” and Δmag $\sim$ 16.5 at 1.5” in H band, sufficient to rule out M-type companions.

Detection and characterisation of protoplanets with JWST/MIRI
Margot Courtoux (Observatoire de Paris -LIRA)

Direct imaging of exoplanets can be challenging due to the high contrast with their host stars and their small angular separations. In particular, young planetary systems are surrounded by circumplanetary disks (CPDs) that are accreting gas and dust. This material increases the opacity, thereby reducing the luminosity of the embedded planet. Until now, only a few young systems hosting protoplanets have been detected robustly in the near-infrared with VLT/SPHERE (PDS70bc, WISPIT 2b). The coronagraphs of the MIRI instrument onboard JWST offer a new opportunity to observe young exoplanetary systems at mid-infrared wavelengths, while preserving high-contrast imaging and angular resolution. MIRI is recognized as a favorable instrument for detecting and characterizing CPD. However, a new challenge arises from the presence of a circumstellar disk (CSD) in these systems. The warm dust component in the inner ($\sim$10au) regions that are poorly angularly resolved by MIRI produces a diffraction pattern. To detect the CPD, we need to model this diffraction pattern to subtract its contribution from the observations. We will present the first results of our diffraction modeling and subtraction methods applied to publicly available MIRI data of young planetary systems with protoplanet candidates.

Observing Conditions Matter! Enhanced SHINE F150 detection limits with RSM
Mariam Sabalbal (Université de Liège)

The Regime Switching Model (RSM) is a recently introduced statistical framework for planet detection in angular differential imaging (ADI) sequences. This advanced detection algorithm demonstrates enhanced capability in distinguishing planetary signals from bright speckles while simultaneously leveraging multiple ADI-based techniques. We apply the RSM algorithm to the F150 sample of the SHINE survey obtained with SPHERE/VLT, aiming to push current detection limits and reveal new candidate companions. We focus on understanding the impact of environmental conditions on post-processed noise distributions and detection limits. In this study, we employ a clustering approach based on environmental parameters to classify observations into groups with similar noise characteristics. Two approaches are proposed to define detection thresholds as a function of angular separation in the RSM probability maps: fitting a log-normal distribution to the residual noise and maximizing the F1 score. We examine the differences between these techniques and the influence of observing conditions on noise behaviour in the RSM maps. This study demonstrates the utility of clustering based on observational parameters, effectively distinguishing features such as wind-driven halos, low-wind effects, and poor observing conditions. Detection thresholds in the final maps vary significantly across clusters, differing by up to a factor of 10, highlighting the importance of accounting for observational environments. Thresholds derived from log-normal distributions provide conservative, noise-aware detection limits, while maximum-F1-score thresholds yield observation-specific limits, both showing overall consistency. Detection limits obtained with RSM are on average improved by a factor of two at 1 arcsec and five at 0.1 arcsec relative to standard annular PCA processing, with gains of up to eight under poor conditions.

Model-Based Phase Retrieval for JWST Coronagraphy and High-Contrast Imaging
Marie Ygouf (Jet Propulsion Laboratory)

High-contrast imaging of exoplanetary systems requires robust post-processing to detect faint companions amidst bright stellar light. We present a model-based coronagraphic phase retrieval method under active development for JWST high contrast imaging observations, validated on simulated datasets and currently applied to JWST NIRCam and NIRISS AMI data, with ongoing work to achieve robust convergence across different observations. The approach leverages a physically informed instrument model to estimate the wavefront and reduce PSF residuals, providing a robust framework for PSF subtraction and post-processing without reliance on traditional reference stars. By integrating instrument modeling directly into the analysis pipeline, this method informs observing strategies, calibration approaches, and post-processing techniques for upcoming missions, including the Roman Coronagraph Instrument and the Habitable Worlds Observatory. These efforts aim to showcase how model-based approaches can enhance high-contrast imaging and guide the development of future flagship missions.

Mid-infrared spectroscopy of cold directly imaged giant planets with JWST/MIRI.
Mathilde Malin (STScI / Johns Hopkins University)

The James Webb Space Telescope is revolutionizing our understanding of directly imaged exoplanets by providing unprecedented access to the mid-infrared. Its MIRI instrument uniquely delivers medium-resolution spectroscopy, ideally suited to probing the atmospheres of cold, giant planets on wide orbits. I will present MIRI spectroscopic observations of one of the coldest planetary-mass companions: GJ 504 b. We applied cross-correlation "molecular mapping" techniques, which effectively reveal atmospheric composition. We detect many molecular features, including a direct confirmation of NH3, a proxy for surface gravity and thus planetary mass. Carbon dioxide is detected for the first time and enables us to measure the atmospheric metallicity with greater precision. Measuring molecular abundances is key to understand the planet's formation and evolution pathway. To further refine the characterization of their atmospheres, we carefully subtracted the host star's diffraction pattern using referential differential imaging (RDI) adapted for spectro-imaging data. Finally, I will present predictions for probing the molecular content of even colder planets, including the recently detected Saturn-mass planet TWA7 b, using JWST/MIRI spectroscopy. These results illustrate how MIRI is enabling direct atmospheric studies of long-period giant planets, providing new insights into planetary formation and evolution. This also demonstrates the broader potential of these methods for future integral field spectrographs.

Preparing for Launch: The Roman Coronagraph Instrument Community Participation Program
Maxwell Millar-Blanchaer (UCSB)

With an expected launch date in Fall 2026, the Nancy Grace Roman Space Telescope's Coronagraph Instrument is set to pave new ground for the field of exoplanet direct imaging. The instrument is a dedicated coronagraph instrument that will for the first time demonstrate high-order wavefront control in space. The mission is a key milestone in demonstrating technologies necessary for the

Habitable Worlds Observatory, while at the same time it has the potential to carry out innovative scientific programs inaccessible to current ground and space-based instruments. The Community Participation Program (CPP) is an international collaboration charged with preparing for launch. Collectively the CPP is responsible for planning the observational strategy and priorities, developing a data reduction pipeline and simulation suite, and exploring pathways to enabling advanced hardware and wavefront sensing modes. Here I will provide an overview of these CPP's activities and provide a look forward for what to expect up to and beyond launch.

Wavefront Sensing in Colour Using the Gradient Descent Reconstructor and Microwave Kinetic Inductance Detectors (MKIDs)
Michiel Darcis (SRON / Leiden Observatory)

Future high-contrast imaging instruments require highly precise wavefront sensing to achieve their goals. A promising way to improve wavefront sensors is to utilize currently under-exploited wavelength information. This is facilitated by new developments in detector technologies and non-linear wavefront reconstructors. Microwave Kinetic Inductance Detectors (MKIDs) can obtain a low-resolution spectrum without dispersive optics, making it possible to take multi-wavelength measurements without changing the optical architecture. In addition, reconstructors like the recently proposed accelerated gradient descent method can take these multi-wavelength measurements into account in the wavefront reconstruction. The presented work examines the advantages of using multi-wavelength reconstruction for the Zernike Wavefront Sensor (ZWFS). Using numerical simulations, we investigated the improvement in performance of both the scalar and vector ZWFS. In addition, lab measurements are performed on the testbed in SRON. The setup consists of a deformable mirror, scalar Zernike mask and MKID array. The first results are presented from the system.

Coronagraphic postprocessing using a forward-modeling approach with bootstrapping
Natalia Sanchez-Soria (University of Rochester)

The contrast level that can be achieved with a coronagraph instrument is limited by optical aberrations, as they result in additional starlight getting through the system. To correct this, a combination of wavefront control and postprocessing is required. Postprocessing requires the estimation of the aberrated stellar point spread function (PSF), which is subtracted from the target image to ideally result in just the planet light and residual photon noise. Conventional postprocessing methods estimate the PSF by using reference images of similar stars, rotating the telescope, or probing deformable mirrors. Forward-modeling postprocessing approaches leverage wavefront information to obtain a PSF estimate, without requiring moving the telescope or taking additional images. In this work, we implemented a forward-modeling approach using a nonlinear optimizer, L-BFGS, to solve for the wavefront error that results in a simulated image that best subtracts the residual starlight in the target image. We implemented a bootstrapping approach that cycles between optimizing aberration coefficients and optimizing the wavefront on a point-by-point basis. This approach resulted in a higher planet SNR than only optimizing either the coefficients or the wavefront point by point. Our simulations assumed the amplitude-apodized vortex coronagraph (AAVC) design for the HWO Exploratory Analytic Concept 1 (EAC-1) and included phase-only aberrations in the pupil plane that varied with time as a Gaussian random process. Our simulations so far show performance that is close to that of traditional postprocessing methods under the same scenario, but without having to move the telescope.

CorGI-REx Reference Star Vetting for the Roman Coronagraph – Northern Hemisphere Interferometric Observations with the CHARA Array
Nicholas Thomas Schragal (University of Arizona)

The Nancy Grace Roman Space Telescope (Roman) Coronagraph Instrument (CGI) will be a critical technological pathfinder for the Habitable Worlds Observatory (HWO), demonstrating advanced wavefront sensing and control in space for the direct detection and characterization of Jovian exoplanets around nearby stars. Observing sequences with CGI will employ repeated observations of reference stars which must be bright (V¡3), have small resolved diameters (¡2 mas), and be single.

The CoronaGraph Instrument Reference stars for Exoplanets program (CorGI-REx) aims to evaluate the list of candidate reference stars against these requirements with observations from direct imaging, speckle observations, and interferometry. Here we present current progress on the CorGI-REx northern hemisphere near-infrared interferometry campaign. We employ the Center for High Angular Resolution Astronomy (CHARA) Array's MIRC-X and MYSTIC instruments to observe 26 reference stars in the H and K bands with a minimum spatial resolution of 1 mas and a maximum field of view of 430 mas. This enables a search for companions with brightnesses 100 times fainter than the primary star within this region. We use the python package PMOIRED (Parametric Modeling of Optical InteRferomEtric Data) to identify signatures of stellar companions from closure phases and squared visibilities. Further, we directly measure reference star diameters and compare to previous measurements and model estimates. Companion detection limits are estimated for all reference stars and, for tentative detections of companions, flux ratios and positions are estimated.

The JWST/MIRI view of HR 2562 b and κ And b

Nicolas Godoy (Aix Marseille Université, CNRS, CNES, LAM, Marseille, France)

The new generation of space telescopes is opening a window for the detailed characterization of exoplanets. In particular, JWST/MIRI provides a unique opportunity to study the young exoplanet population through thermal emission (MIR). Combined with ground-based NIR observations, this allows us to cover more than 90% of the bolometric flux of these objects. We present the first results from our GTO program focused on the characterization of two out of four planetary-mass companions: HR 2562 b and κ And b. Our main goal is to better constrain the effective temperature and radius, as well as other key physical parameters such as mass and age. Using MIRI coronagraphic observations in the F1065C, F1140C, and F1550C filters, we probed the atmospheric properties of both objects. HR 2562 b lies in the L/T transition, with a poorly constrained age and physical parameters (mass $<$ 18 MJ, Teff = 1200-1700 K, log g = 4-5). κ And b, an L-type companion, has been the subject of a decade-long debate regarding its age (7-300 Myr) and atmospheric properties (e.g., Teff = 1650-2050 K, log g = 3.5-5.5). Our results significantly narrow down the atmospheric parameters of both companions, particularly Teff and radius, and provide more precise, model-dependent estimates of κ And b's age and mass. In addition, our work includes improvements in data reduction that have already been integrated into community tools. These results demonstrate that JWST/MIRI is a transformative instrument for advancing our understanding of planetary atmospheres.

NIRCam yells at cloud: How non-chronographic MIRI imaging can directly detect exoplanets as cold as Saturn and Jupiter that other modes might miss

Rachel Bowens-Rubin (Eureka Scientific)

NIRCam and MIRI coronagraphy have successfully demonstrated the ability to directly image young sub-Jupiter mass and mature gas-giant exoplanets. However, these modes struggle to reach the sensitivities needed to find the population of cold giant planets that are similar to our own Solar System's giant planets (Teff=60-125 K; a=5-30 AU). I'll share updates from two JWST programs (GO 6122: Cool Kids on the Block & SURVEY 8581: Hot On The Hunt for frigid exoplanets) which demonstrate that non-coronagraphic F2100W MIRI imaging can be used to detect planets with the same temperature, mass, age, and orbital separations as Saturn within 3pc and Jupiter within 7pc. We find that the sensitivities of our NIRCam coronagraphy observations can only achieve similar results in the unlikely case that a cold giant planet is cloud-free. This discrepancy highlights a broader concern: direct imaging surveys performed with NIRCam alone may be systematically undercounting the number of planets colder than 350 K that exist. These results highlight the importance of coupling mid-IR observations to constrain a planet's temperature and mass with the near-IR observations that probe atmospheric chemistry to get a holistic view into the diversity of worlds that we expect to see in the cold giant exoplanet population.

JWST telemetry combined with active coronagraphy: inferring raw contrast predictions for exoplanet imaging with the Habitable Worlds Observatory

Raphaël Pourcelot (MPIA)

JWST wavefront sensing of the current state-of-the-art in stable space telescopes provides a basis to assess wavefront control for future observatories. NASA's Habitable Worlds Observatory (HWO) seeks to detect and spectrally characterize Earth-like exoplanets orbiting Sun-like stars, a task requiring down to picometer-level wavefront stability for certain modes over multi-hour integrations. This demands both ultra-stable optical structures and high-performance active wavefront sensing and control (WFS&C). While the James Webb Space Telescope (JWST) routinely achieves nanometer drifts over day timescales. During commissioning its thermal response was characterized thoroughly, with an overall measurement precision of 0.1 nm. Yet it does not feature modern coronagraphic techniques such as optimized coronagraph mask or active wavefront control. HWO will most certainly take advantage of the two decades of advances in high contrast since the design of Webb. In this study, we use JWST's in-flight primary mirror segment piston/tip/tilt natural guide star metrology, a next-generation Apodized Pupil Lyot Coronagraph (APLC) design, and a WFS&C architecture adapted from the Roman Space Telescope's Coronagraph Instrument (CGI) to estimate what the residual wavefront errors would be if the drifts captured by metrology were corrected using an Adaptive Optics architecture, under the illumination of the natural guide star. We explore multiple system architectures, including variations in deformable mirror (DM) and wavefront sensor configurations and whether or not the primary mirror is used for segment-level wavefront correction. By analyzing these residuals, we use end to end simulation to quantify the raw contrast maintained by the instrument in the presence of telescope drifts. With the combination of simulations of wavefront control with JWST's thermal evolution metrology, we assess how current architectures perform under HWO-like conditions, clarifying the challenges in achieving the stability and contrast needed for direct imaging of Earth analogs.

The SPHERE and JWST view of the complex circumbinary disk of DG CrA
Rob van Holstein (European Southern Observatory)

Multiple star systems are challenging environments for the formation of planets. Tidal interactions between a binary star and its planet-forming disk can truncate the disk and induce cavities, spirals, and warps in the disk. Interactions between the disk and the interstellar environment can create additional complex features. Furthermore, forming planets can be ejected from the system through dynamic interactions with the binary star, potentially explaining (part of) the observed populations of free-floating planets and directly imaged wide-orbit giant planets. As part of the DESTINYS large program with SPHERE at the VLT, we observed the young, nearby binary system DG CrA. We spatially resolve both stellar components and detect an extended circumbinary disk with complex substructures and spirals in near-infrared, (polarized) scattered light. One striking substructure is a radial, tail-like feature that starts at the inner disk region and extends outward beyond the outer edge of the circumbinary disk. From hydrodynamic modeling we find that this feature is possibly caused by the recent ejection of a planet. To obtain a deeper image of the disk and detect this planet, we took follow-up observations of DG CrA with JWST-NIRCam. We detect several planet candidates at large angular separations from the central binary and put stringent upper limits on the mass of potential planets in the close vicinity of the disk. By combining reference-star differential imaging and deconvolution techniques, we spatially resolve the disk at 2 um. From these images, we detect large-scale structures that may be due to ongoing interactions of the disk with the interstellar environment. The unique DG CrA system has the potential to become a benchmark for the study of star-planet-disk interactions, the formation and ejection of planets around binary stars, and the interaction of disks with their interstellar environment.

JWST NIRCam Detections of Sub-Jupiter Companion Candidates and a Multi-Component Debris Disk
Rohan Kane (Space Telescope Science Institute, Towson University)

We present the detection of a debris disk system with two companion candidates directly imaged with JWST NIRCam. Such systems are often inferred from disk asymmetries and direct detections of both planets and the disk are rare due to the low threshold on planet mass required to sculpt the disk. However, through using carefully selected archival reference stars we can supplement the PSF library used to model the data and push the detection threshold into the higher-contrast parameter space these sculptors occupy. In our 4.4 μm image we identify two sub-Jupiter companion candidates at separations of 1" and 1.6" (18 and 28 au) embedded in a disk component that we model to a PA

$\sim$20° offset from the PA fit to the 2 μm image. We subtract the multi-component disk model fit the photometries to the candidates to assess their role in driving the asymmetry. The candidate at 1" has an F444W absolute magnitude of 18.6, which the Sonora Bobcat isochrones fit to an upper limit of 0.55 MJ, and the candidate at 1.6" has an F444W absolute magnitude of 17.4, which the Sonora Bobcat isochrones fit to an upper limit of 0.75 MJ. The projected separation of the closer candidate as a minimum orbital radius lies outside of the Hill radius of the disk, allowing it to sculpt the inner edge of the disk. The projected separation of the second candidate lies within the Hill radius, implying that it would disrupt the disk material. The study of this system offers a valuable example to further understand the circumstellar environments of young late-type stars.

A First Look with JWST Aperture Masking Interferometry: Resolving Circumstellar Dust around a Colliding-Wind Binary

Ryan Lau (Caltech/IPAC)

The aperture-masking interferometry (AMI) mode on JWST's Near Infrared Imager and Slitless Spectrograph (NIRISS) enables the highest angular resolution on JWST and showcases the advantages of space-based infrared (IR) interferometry. This observing mode presents an ideal opportunity to investigate dust formation from colliding-wind Wolf-Rayet (WR) binaries, which are potential dust factories and rapid sources of dust production. In this talk, I will present infrared NIRISS AMI observations of newly formed dust from the colliding winds of the massive binary Wolf–Rayet system WR 137. Interferometric observables (squared visibilities and closure phases) from the WR 137 "interferogram" were extracted and calibrated using three independent software tools: ImPlaneIA, AMICAL, and SAMpip. The analysis of the calibrated observables yielded consistent values except for slightly discrepant closure phases measured by ImPlaneIA. Based on all three sets of calibrated observables, images were reconstructed using three independent software tools: BSMEM, IRBis, and SQUEEZE. All reconstructed image combinations generated consistent images. The reconstructed images of WR 137 reveal a bright central core with a 300 mas linear filament extending to the northwest. A geometric colliding-wind model with dust production constrained to the orbital plane of the binary system and enhanced as the system approaches periapsis provided a general agreement with the interferometric observables and reconstructed images. Based on a colliding-wind dust condensation analysis, we suggest that dust formation within the orbital plane of WR 137 is induced by enhanced equatorial mass loss from the rapidly rotating O9 companion star, whose axis of rotation is aligned with that of the orbit.

Incorporating Wavefront Error, Wavefront Sensing and Control, and Sensitivities into Exposure Time Calculations with the Error Budget Software (EBS)

Sarah Steiger (Space Telescope Science Institute)

HWO's goal of imaging $\sim$ 100 star systems and acquiring spectra of $\sim$ 25 rocky planets (with planet/star flux ratios of 10^{-10}), places tight constraints on the performance of all observatory systems. In particular, coronagraph instrumentation needs to be matured for higher throughput, deeper contrasts, and better broadband performance, while also considering their sensitivity and ability to mitigate the impact of telescope instability and wavefront error (WFE) which can have a profound impact exo-Earth imaging. Due to the specific focus on the quantity of observed/characterized exo-Earths, the success of various HWO mission architectures is often represented by the estimated exo-Earth candidate (EEC) yield, which is calculated by mission simulators, packaged as yield codes. Computation of the minimum exposure time to achieve required SNR on given target, using an exposure-time calculator (ETC), is a key part of yield estimation. Moreover, one relies on ETCs not only for yields, but also to identify key observatory parameters that have large effects on expected exposure, warranting more in-depth study. The impact of stability, WFE, and WFS&C has been well studied in the context of developing error budgets for missions and instruments such as Roman CGI. Despite this, there is currently no easily accessible way to directly incorporate the impact of WFE, stability, and WFS&C into calculating exposure times to perform trade studies for HWO. To address this gap, we present the Error Budget Software (EBS) – an open-source tool that synthesizes WFE, stability, and WFS&C information for a variety of temporal and spatial scales, which directly feeds into EXOSIMS to produce exposure times. Using EBS we also show some preliminary studies highlighting the interplay between key variables such as raw contrast and wavefront error, and detector noise and spectral resolution which can have a large impact on exo-Earth exposure times.

X-SHYNE: A multi-approach analysis of 43 planetary analogue near-infrared medium-resolution spectra
Simon Petrus (NASA Goddard Space Flight Center)

Characterizing exoplanet and brown dwarf spectra is key to probing atmospheric processes and constraining their formation pathways. The X-SHYNE library is a homogeneous sample of 43 medium-resolution (R$\lambda \approx$ 8000) near-infrared (0.3–2.5 μm) spectra of young (<500 Myr), low-mass (<20 MJup), and cold (Teff $\approx$ 600–2000 K) isolated brown dwarfs and wide-orbit companions obtained with VLT/X-Shooter. We analysed it using two complementary approaches. 1) A semi-empirical method, refining age and bolometric luminosity, yielded Teff, mass, log(g), and radius through COND03 evolutionary tracks. And 2) a synthetic analysis with three self-consistent atmospheric models using the Bayesian inference code ForMoSA. In my talk, I will present and discuss the results of both methods that gave consistent bolometric luminosities, but different Teff, log(g), and radius. We interpreted this as a results of a bias linked to cloud dynamics. Specifically, rotationally driven cloud migration toward the equator combined with viewing-angle effects alters the observed atmospheric properties. This interpretation is supported by correlations between the J–K color anomaly, log(g), and the cloud sedimentation parameter fsed. Lastly, while robust [M/H] and C/O constraints remain challenging for individual objects, the library as a whole suggests near-solar values, consistent with stellar-like formation. Overall, X-SHYNE demonstrates the power of homogeneous datasets for comparative atmospheric studies, mitigating systematics and enabling robust conclusions while avoiding overinterpretation.

Simulating Roman Coronagraph Observations with CorgiSim and CPGS
Sophie Noiret (Laboratoire d'Astrophysique de Marseille)

The Nancy Grace Roman Telescope, to be launched in 2026, will carry the Roman Coronagraphic Instrument (Roman CGI), a technology demonstration which aims at achieving extremely high contrast. As a secondary goal, the Roman CGI will enable the direct imaging of giant exoplanets in reflected light. To prepare for these observations and to support the development of analysis tools, we are developing CorgiSim, a simulation suite for the Roman CGI.CorgiSim is a python software built on established optical propagation libraries such as PROPER and CGISim. Available on github, it allows the user to generate synthetic level 1 data, i.e. detector readout in FITS files that closely mimic the telescope's output.In this poster, we present an overview of CorgiSim's functionalities, with particular emphasis on its integration with the Command Product Generation Software (CPGS). This tool enables users to simulate complete observational sequences of the Roman Coronagraph, using the bandpasses, coronagraphic masks, and instrument modes specified in the command product.

Probing the ELT's limits towards Earth-like planets: costs and gains of molecular mapping
Steven Martos (IPAG)

Detecting Earth-like exoplanets is one of the most ambitious goals of the ELT. The distinctive spectral features of such planets can be critical to disentangling the companion signal from noise and stellar residuals. We present performance predictions for molecular mapping, a high-resolution cross-correlation technique, applied to PCS, the ELT instrument dedicated to exoplanet and disk studies through a multi-stage extreme adaptive optics system, coronagraphs, and spectrographic capabilities. Using the semi-analytical FastCurves framework validated on JWST/MIRI data, we estimate achievable contrasts and signal-to-noise ratios for temperate planets, accounting for both fundamental and potential systematic noise. We place PCS in context with the other ELT IFUs (HARMONI, ANDES, METIS), and compare molecular mapping with ADI and RDI, quantifying the temporal speckle stability required for these techniques to become more competitive. Finally, we identify the optimal spectral band and resolution for PCS, underscoring its potential to detect and characterize Earth analogs.

Searching for planets around Altair with JWST

Tiffany Meshkat (IPAC/Caltech)

Altair is one of our nearest neighbors (5.13 pc) and its age has recently been revised to a much lower 88 Myr. It is now among the youngest nearby stars, making it an ideal candidate for exoplanet direct imaging searches with JWST. NIRCam/JWST observations of Altair have revealed a few exciting candidate companions. Assuming an age of 88 Myr, the closest of these candidates corresponds to a mass of 0.5 Jupiter masses at a separation of 16 au. Here we present the results of second epoch NIRCam observations of these candidates. These candidates – if confirmed – would be the target of significant follow-up for characterization.

Polarimetry of the Nancy Grace Roman Space Telescope Coronagraph Instrument

Toshiyuki Mizuki (Astrobiology Center of NINS)

The Roman Space Telescope will carry the Coronagraph Instrument, capable of high-contrast polarimetry at visible wavelengths. To enable the characterization of dust grains in warm debris disks and planetary polarization, it is essential to calibrate its polarization response using on-sky sources and to implement dedicated polarimetry functions within the data reduction pipeline, corgiDRP. Polarization aberrations are expected to limit the achievable polarized contrast in the deeper observations with both Roman and the future Habitable Worlds Observatory, underscoring the importance of calibration. Since the summer of 2024, a polarimetry working group has been established within the Community Participation Program Team to maximize the scientific return of the technology demonstration activities and to facilitate community-wide use. We summarize the selection and precursor observations of polarimetric standard stars, the calibration plan, and the current capabilities of the polarimetry functions in corgiDRP, along with plans to verify polarized speckles. Finally, we show that Roman's polarimetry is ready for science applications.

High-Dimensional Artificial Intelligence Modeling for Predicting Exoplanetary Atmospheric Absorption Spectra

Vasuda Trehan (University at Albany, SUNY)

The research presents a scalable machine learning model and Bayesian inference framework that will predict atmospheric absorption spectra across a high-dimensional space of data with up to 30 planetary parameters such as mass, radius, surface temperature, stellar type, orbital parameters, and more. Each contributes to the complexity of the modeling challenge. Traditional interpolation techniques, such as Piecewise Cubic Hermite Interpolating Polynomial (PCHIP) or splines, quickly become inefficient as dimensionality increases, limiting their applicability in modern exoplanet research. This research introduces a scalable, non-parametric Bayesian framework using Gaussian Process Regression (GPR) to serve as a forward model for predicting exoplanetary spectra. Our approach integrates various kernel function optimizations to better capture complex, non-linear spectral variations, and Bayesian Adaptive Exploration to prioritize informative sampling, reducing the number of required simulations without sacrificing accuracy. We also incorporate nested sampling to efficiently explore the posterior over kernel hyperparameters and spectral outputs in high-dimensional settings. Using simulated data from NASA's ROCKE-3D General Circulation Model (GCM), we ensure that our model achieves accurate spectral predictions across a broad range of exoplanetary conditions, including varying masses, radii, stellar types, surface temperatures, and orbital characteristics. The framework not only predicts spectra but can also invert observations to estimate underlying planetary properties which can indicate the planet's habitability.

The COBREX archival survey: a direct imaging view of planet formation

Vito Squicciarini (University of Exeter)

Radial velocity studies targeting evolved stars have shown that giant planets are more commonly found around metal-rich hosts, around more massive stars, and tend to be clustered around the ice line. However, the critical 5-20 au region, where Jupiter and Saturn reside, is poorly constrained by this method. Direct imaging (DI), the only method capable of targeting planetary systems in their infancy, has the potential to fill this gap. While waiting for ground-breaking technological advancements such as those predicted for the ELT and Roman, state-of-the-art post-processing algorithms can enable the detection of faint companions that had been previously overlooked in archival data. Within the ERC-funded COBREX project, we collected thousands of archival observations from the ground-based DI instruments SPHERE and GPI; these data were uniformly reduced using the PACO algorithm. I will present the tantalizing results of this endeavor: coupling the re-analysis of 400 stars from the GPIES survey (Squicciarini+24), the final analysis of SHINE (Chomez+25), and smaller programs, we assembled a sample of ∼1000 stars, by far the largest survey of young stars to date. Thanks to the exquisite detection sensitivity and the large sample size, we derived the most precise constraints on wide giant planet frequency ever obtained by DI, allowing for a comparison with the competing giant planet formation models of core accretion and gravitational instability. In addition to this, the project led to the discovery of a 6 M_Jup planet orbiting the binary HD 143811, the second planet detected with GPI. HD 143811 b is one of the few circumstellar planets to be imaged to date, and the first one with a < 100 au. Its peculiarities raise exciting questions about its formation and its relationship with single-star companions and free-floating planets — urging for dedicated orbital and spectroscopic follow-up studies.

Colder, closer: Pushing the limits of JWST Coronagraphy
William O Balmer (Johns Hopkins University)

Coronagraphy with JWST was expected to comfortably achieve contrasts of 1e-5 at a few arcseconds, sensitive to warm, wide separation super-Jupiters that have an extremely low occurrence rate. Most planets orbit at closer separations and have much lower masses. I will present on my team's work pushing JWST coronagraphy to close-in separations (<0.5"), showcasing new Cycle 4 images with a novel coronagraphic technique. These images trace the carbon dioxide content of a number of enigmatic planets, revealing their true atmospheric metallicities for the first time. These results have exciting implications for the timescale and mechanisms of giant planet formation. I will also show how my team has pushed wide separation coronagraphy to deeper contrasts (1e-6 at 1"), which enable the detection of truly "cold" giant planets for the first time. I will present images of 14 Herculis and HD 222237, two systems hosting giant planets on eccentric orbits. These cold giants trace the thermal and dynamical evolution of planetary systems, and reveal the violet history of planet-planet interactions.

Interpretable Deep Transfer Learning for Protoplanetary Disk Classification in Polarimetric Imaging
Yi Yang (The Astrobiology Center)

High-contrast polarimetric imaging has enabled direct studies of protoplanetary disks, but the growing number of targets calls for efficient, automated classification methods. We present a pilot study applying deep learning to Polarimetric Differential Imaging (PDI) data from the public POLARIS archive (VLT/SPHERE IRDIS). Using a transfer learning approach with a ResNet18 backbone adapted for 1-channel FITS input, our model distinguishes disks from reference images with 80–90% validation accuracy despite the small dataset size (96 images). Explainability techniques like Grad-CAM confirm that the network attends to disk regions in successful cases, while misclassifications reveal sensitivity to residual speckles and background noise. These results demonstrate the feasibility of machine learning–based classification of disks, while highlighting the need for larger datasets, improved preprocessing, and integration of domain knowledge. This work outlines a framework for scaling ML approaches to upcoming high-contrast imaging surveys with VLT, Subaru, and JWST.

Time-Resolved Coronagraphic Observations with JWST: Accessing the Rotational and Atmospheric Dynamics of Directly Imaged Exoplanets
Yifan Zhou (University of Virginia)

Time-resolved observations represent a critical yet underutilized capability in high-contrast imaging. Direct measurements of planetary rotation periods constrain angular momentum evolution. Longitudinal mapping of atmospheric features reveals the spatial distribution of clouds, hazes, and temperature variations. These observations provide fundamental constraints on atmospheric circulation models. Time-series photometry can also detect transiting satellites around directly imaged planets. Space-based coronagraphic observations deliver the photometric stability necessary for these studies. Since Cycle 3, pilot coronagraphic monitoring programs have been executed with JWST. The data demonstrate systematic errors at levels near the photon noise limit. Photometric precision of the time series exceeds ground-based measurements by more than an order of magnitude. These observations provide the first direct probes of heterogeneous atmospheric structures in directly imaged exoplanets. Preliminary results reveal rotational modulations and constrain the longitudinal distribution of cloud features. The demonstrated performance establishes JWST as the premier facility for time-domain studies of self-luminous planets. This presentation will discuss the technical performance, initial science results, and the pathway toward large-scale monitoring campaigns of directly imaged planets with JWST.

A Search for Wide-orbit Planets Around M-dwarfs using Deep MIRI 15-micron Images
Yihan Li (Peking University)

Wide-orbit gas giants (¿10 AU) shape planetary system architecture. Recent JWST/MIRI time series observations targeting rocky planets around M dwarfs provide sensitive probes for wide-orbit companions through high-contrast imaging analysis. Here we present a direct imaging search for such planets leveraging archival 15 micron time-series observations. By applying Reference Star Differential Imaging for MIRI/F1500W images of ten transiting-planet hosting M dwarfs, we achieve a median 5-sigma planet-to-star contrast of 1.5e-3 (median apparent magnitude of 16.4 mag) at a separation of 1" and 2.1e-4 (18.5 mag) at separations beyond 3". The sensitivity is converted to planet detection probability for each system as a function of planet mass versus semimajor axis. Assuming solar metallicity and clear atmosphere, we are sensitive to planets with Jupiter-like radius and 1-bar temperature (170 K) at separations of 35 AU in systems at 12.5 pc. Furthermore, we create a catalog of the nearby sources and estimate their possible impact on future observations assuming they are background sources. Our results demonstrate that archival MIRI time-series data is a powerful window for direct imaging surveys of wide-orbit gas giants around M-dwarfs.

Characterizing the TW Hya System with JWST/NIRCam: Fine-Scale Disk Architecture and Deep Companion Limits
Yu-Chia Lin (University of Arizona)

We present high-contrast coronagraphic images of the TW Hya protoplanetary system from JWST/NIRCam in four filters (F187N, F200W, F356W, F444W). In the absence of a contemporary reference star, we constructed a PSF library from archival observations to perform High-Pass Filter Reference Differential Imaging (HPFRDI). Subsequent Richardson–Lucy deconvolution enhanced fine-scale features, enabling detailed structural analysis. We confirm a bifurcation structure at $\sim$120 AU, previously identified in HST and SPHERE observations. The disk's geometric framework is established using an MCMC-based elliptical fitting routine, which minimizes azimuthal brightness variance to determine the parameters that render the deprojected disk most circularly symmetric. Our companion search yields no new detections, setting a stringent, age-dependent upper limit of $\sim$0.6 Jupiter mass beyond 60 AU (1"), assuming an 8 Myr system age. The characterization of the bifurcation and the deep companion limit provides direct, quantitative constraints for hydrodynamical models of planet-disk interaction in the TW Hya system. This work also validates archival reference-star differential imaging as a powerful method to leverage JWST's stability and resolve the fine-scale architecture of protoplanetary disks.

Poster Session 2

3 Poster Presentations: Session 2

Black Silicon Apodizer Results Relevant to the Habitable Worlds Observatory
A J Eldorado Riggs (JPL)

After demonstrating high-contrast imaging with the Roman Space Telescope Coronagraph Instrument, NASA proposes to image and characterize terrestrial exoplanets at 1e-10 planet-to-star contrast with the Habitable Worlds Observatory (HWO). To facilitate the launch of a $\geq$6-meter aperture, HWO's primary mirror will most likely be segmented. This segmentation requires apodization, either with deformable mirrors or a dedicated mask, to suppress the extra diffraction introduced. Reflective apodizers using black silicon and aluminum for the Roman Coronagraph have been flight qualified and demonstrated 4e-9 contrast. With our current efforts, we are working to show that black silicon apodizers can be used by HWO to achieve 1e-10 contrast. In our first milestone, we recently measured the incoherent light contribution from light scattered off the black silicon is <4e-13 contrast in the Decadal Survey Testbed 2 (DST-2) vacuum bench. Are next to milestones are to achieve <5e-10 contrast on DST-2 with a shaped pupil coronagraph and to develop and validate an FDTD model of polarization aberrations from small apodizer features. Here we present our most recent testbed and modeling results.

Recovering Full-Field Spectra with SPIDERS' IFTS: First On-Sky Results at Subaru
Adam Johnson (NRC-HAA)

We report the first on-sky demonstration of the SPIDERS imaging Fourier transform spectrometer (IFTS) behind a second-stage adaptive optics (AO) coronagraphic system at the Subaru Telescope. Operating over a 3.3" $\times$ 3.3" AO-corrected field, the IFTS produces full-field interferometric datacubes with selectable spectral resolution from R15 to R15,000 for broadband or narrowband spectroscopy. It employs a continuous-scan Michelson interferometer with a custom nanometer-scale path control system, driven by a voice-coil actuator and stabilized by a precision fringe-quadrature metrology loop to maintain accurate and repeatable modulation under variable conditions. Commissioning in December 2025 will validate the interferometric control hardware on sky and demonstrate spectral reconstruction across the corrected field, including tests of system chromaticity, calibration accuracy, reconstruction accuracy, and vibration rejection. By delivering spatially resolved spectra across the coronagraphic focal plane, the IFTS will enable spectral differential imaging (SDI) to suppress quasi-static speckles and improve sensitivity to faint structures. This run will mark the first demonstration of a full-field IFTS integrated with a second-stage AO system and coronagraphy, establishing instrument performance and providing a foundation for future applications in exoplanet characterization, circumstellar disk studies, and high-resolution imaging spectroscopy on large observatories.

On-sky demonstration of second-stage wavefront control with a photonic lantern
Aditya Rohan Sengupta (University of California, Santa Cruz)

Ground-based direct imaging of exoplanets at high contrast requires precise correction of atmospheric turbulence using adaptive optics (AO). The planet-to-star contrast ratio at small angular separations from the host star is often limited by non-common-path aberrations seen only in the science plane. The photonic lantern (PL) can be used to sense aberrations at the final science imaging plane. This enables a two-stage wavefront control architecture, in which the first-stage wavefront sensor senses atmospheric turbulence and the PL senses NCPAs and other aberrations not seen by the first stage. We demonstrate closed-loop control of residual wavefront errors using a non-dispersed PL after first-stage AO correction on the Shane 3m telescope at Lick Observatory. Our results show that non-dispersed PLs can be used for second-stage wavefront sensing, enabling minimally invasive retrofits to existing AO systems.

High-contrast NIR spectro-imaging capability with ELT/HARMONI
Alexis Carlotti (UGA / CNRS / IPAG)

HARMONI - the NIR integral field spectrograph of the ELT - will include a high-contrast imaging capability with a minimum separation down to 30mas in the H band. Following a recent rescope phase, the instrument will offer a spectral resolution up to R=7100 to study planets and disks in the J, H, and K bands in a 1" large, Nyquist-sampled FoV. In particular, it will be capable of characterizing 1-3 MJup planets as close as 1 AU to young stars at 20pc, nicely matching the expected detection capability of GAIA. HARMONI may also be capable of characterizing a few planets in reflected light. We provide more details on the specifications of the high-contrast imaging capability, and we present its expected contrast limits, which we derive from a numerical model of the instrument that includes realistic AO and NCPA residuals, and other non-ideal effects. We consider two post-processing techniques relying on the temporal diversity of the data (ADI), and on its spectral diversity (molecular mapping). In the latter case we will provide a yield estimate based on the known population of planets.

Machine Learning Wavefront Reconstruction: On-sky Results with SPIDERS
Andre Fogal (University of Victoria)

We will present results from on-sky operation at the Subaru telescope of a machine learning-based wavefront reconstructor on the Subaru Pathfinder Instrument for Detecting Exoplanets and Retrieving Spectra (SPIDERS). SPIDERS uses a Lyot-based Low Order Wavefront Sensor (LLOWFS) to perform pupil-plane wavefront sensing of low spatial order aberrations in the wavefront. The previous method of wavefront reconstruction relied on a linear reconstructor, but this approach struggled with the inherently nonlinear nature of the problem. To address this, we have developed a machine learning-based wavefront reconstructor based on a convolutional neural network that greatly increases the linear range of the LLOWFS, leading to more effective wavefront control. We will show results from in-lab testing and closed-loop operation on-sky, showing stability and linearity improvements over the linear reconstructor while maintaining high prediction speeds (∼70 us), demonstrating the viability of this method for future high contrast imaging instruments.

SCALES: Slicer Combined with Array of Lenslets for Exoplanet Spectroscopy
Andy Skemer (UC Santa Cruz)

SCALES is a new exoplanet imaging spectrograph scheduled to be installed at Keck Observatory in early 2026. The instrument has a 1-5μm imager and a 2-5μm coronagraphic integral field spectrograph with spectral resolutions ranging from R∼35 to R∼7,000, using a novel lenslet array in-series with an image slicer to provide the higher resolutions. By operating at longer wavelengths than other ground-based integral field spectrographs, SCALES is sensitive to colder exoplanets, which will be useful for imaging the astrometric accelerators discovered by GAIA. The long wavelength also allows for detailed characterization of clouds and disequilibrium chemistry at wavelengths where these properties have a significant impact. The moderate spectral resolutions will distinguish protoplanetary disk continua from exoplanet atmosphere absorption features, including accretion lines. Low spectral resolutions will be useful for planetary searches and debris disk characterization. I will discuss SCALES's new technologies, its progress and timeline, and its laboratory performance, as well as some of its anticipated early science cases.

Exoplanet observations with a cascade adaptive optics with a second stage based on a Zernike wavefront sensor: in-lab validation on the ESO/GHOST testbed in broadband light
Anna Rahim (Observatoire de la Cote d'Azur-Lagrange Laboratory)

We present the first in-lab validation of a cascade adaptive optics system with a second-stage control loop based on the Zernike wavefront sensor (ZWFS) in broadband light. Current high-contrast instruments dedicated to exoplanet imaging rely on extreme adaptive optics (XAO) to suppress atmospheric wavefront distortions and deliver diffraction-limited images on large ground-based telescopes. Under typical observing conditions, these systems routinely achieve Strehl ratios above 90% in H-band. However, residual wavefront errors are still left after correction, limiting the ability of these facilities to observe the faintest planetary companions. To overcome these limitations, we investigate a cascade architecture where the current XAO stage is seconded by a control loop based on a ZWFS to address the XAO residuals. Following an initial demonstration in monochromatic light, we present the first experimental validation of this approach in broadband light using the ESO/GHOST testbed. Our results show that the ZWFS-based control loop robustly operates with a 25% spectral bandwidth, leading to similar contrast performance as narrowband operation for bright sources, while chromatic effects become limiting for faint stars. We demonstrate that the removal of non-common path aberrations (NCPA) improves contrast by up to a factor of 2, highlighting their critical impact on system performance. Finally, we test a reinforcement-learning predictive controller (PO4AO), which outperforms the classical integrator by further reducing residual temporal errors under fast turbulence conditions. Overall, our experiments establish the ZWFS-based control loop as a suitable option for cascade AO in broadband light. This approach paves the way for contrast gains beyond current XAO limits, with direct applications to upgrades of current XAO facilities and future ELT-class instruments to observe low-mass exoplanets at small angular separations.

Characterization of the Host Binary of the Directly Imaged Exoplanet HD 143811 AB b

Anne Elisabeth Peck (New Mexico State University)

We present the orbital and stellar parameters of HD 143811 AB, the host star binary to the newly discovered directly imaged planet HD 143811 AB b. HD 143811 AB is a double lined spectroscopic binary and a member of the Sco-Cen star forming region with an age of ~13 Myr. We utilize archival high-resolution spectroscopy from FEROS on the MPG/ESO 2.2-meter telescope to measure radial velocities of both components of the binary and fit the orbit. We use unresolved photometry to fit the SED of the binary and derive the stellar parameters. From the orbit fit we derive a precise orbital period of 18.59098+/-0.00007 days, and mass ratio of 0.885+/-0.003. When we combine the fits with evolutionary models, we find masses of both components of M_A = 1.30+0.03/-0.05 Msun and M_B = 1.15+0.03/-0.04 Msun. While the current data do not rule out the planet and binary orbits being coplanar, additional observations are required to constrain the 3D orientations of both orbits and rigorously test for coplanarity. We discuss the impact of future observations on understanding the host stars, the planet, and their formation and evolutionary history.

Discovery of a Deeply Embedded Substellar Companion in V960 Mon: A Potential Case of Gravitational Instability

Anuroop Dasgupta (European Southern Observatory)

We present the discovery of a faint substellar companion candidate in the young eruptive star system V960 Mon, revealed through high-contrast imaging at 4 μm with the ERIS instrument on the VLT. The object lies at a projected separation of ~0.9" (~400 au) and is deeply embedded within the dusty, asymmetric spiral arms of the extended disk, suggesting formation in a gravitationally unstable environment. Photometric analysis indicates a luminosity consistent with a young, low-mass companion, though significant extinction likely affects the observed flux. This system represents a rare observational case where both large-scale spiral structure and a wide-orbit companion candidate are simultaneously resolved in the thermal infrared, offering compelling evidence for early-stage fragmentation via gravitational instability. Our results underscore the power of ERIS and thermal AO imaging in unveiling deeply embedded companions and provide a valuable benchmark for planet and brown dwarf formation theories at wide separations. This discovery was recently featured in an official ESO press release.

Tricouplers for nulling with photonic integrated circuits

Anusha Janardan Pai Asnodkar (Caltech)

Preliminary demographics combining radial velocity and direct imaging surveys across stellar types suggest that giant planet occurrence rates peak near the snow line between 3-10 AU, an observationally elusive region of parameter space typically falling within the coronographic inner working angle limit of ~2 λ/D for most nearby systems. Nulling interferometry over long baselines distributed across multiple apertures enables starlight suppression at higher spatial resolution than direct imaging, gaining access to the inner region of exoplanetary systems. Leveraging technological advancements from the telecommunications industry, photonic integrated circuits (PICs) offer a promising platform for performing the optical operations necessary for astronomical applications, including

nulling. While PICs provide numerous advantages, such as miniaturization and integration within a substrate to minimize wavefront error from misalignment of bulk optics or thermal/mechanical perturbations, their precision remains insufficient for the stringent requirements of exoplanet instrumentation. Here we investigate different implementations of a photonic tricoupler for nulling. In the laboratory, we characterize broadband nulls in the H-band with devices on a silica-on-silicon platform and explore the chromatic effects from components such as thermo-optic phase shifters necessary for fine-phasing. In simulation, we identify avenues for optimizing the tradeoff between deep achromatic nulling, exoplanet light throughput, and wavefront sensing. Our ongoing efforts towards maturation of PICs for direct detection and atmospheric characterization of exoplanets will support scalable testing and deployment of high-contrast technologies for future space-based observatories, such as the Habitable Worlds Observatory.

Understanding differential limb coupling in diffraction-limited spectrographs on large telescopes
Ashley Baker (Caltech)

Diffraction-limited spectrographs are key instruments for upcoming large telescopes thanks to their compact sizes that do not scale with telescope diameter and their stable point spread functions (PSFs) that are conducive to precise radial velocity (RV) measurements. Interestingly, a new capability of these systems emerges from placing single mode fibers behind AO systems on large aperture telescopes. This combination results in an effect we call differential limb coupling (DLC), which results from the high spatial coupling sensitivity of a SMF that will preferentially couple more of one stellar limb over another if not perfectly centered on a partially resolved star. Here, we discuss the magnitude of the DLC effect for current and planned instruments with a focus on HWO targets of interest and show that utilizing DLC as a stellar characterization tool is within realm for upcoming instruments. We also discuss HISPEC's plans to mitigate DLC for high precision RV measurements and show ongoing work to understand how the performance of an adaptive optics system and uncertainties in the fiber positioning impact the effectiveness of using DLC as a new observational tool.

The Science Potential of Characterizing Gas Giant Planets with HWO
Beck Dacus (UC San Diego)

We investigate the potential scientific return of directly imaging gas giant exoplanets in reflected light using the future Habitable Worlds Observatory (HWO). As part of the search for ∼25 Earth-like worlds, HWO will detect many more planets with large radii at a range of orbital separations. Characterizing the atmospheres of these exoplanets will provide unique insight into planet formation at orbital distances between those of known transiting planets and directly imaged planets. We show that, after 10 hours of integration, HWO will be able to detect water, methane, and ammonia in the atmospheres of planets like Jupiter at a signal-to-noise $S/N \geq 5$ out to 12pc distance. For future retrievals to place meaningful constraints on atmospheric molecular abundances, moderate-to-high-resolution spectroscopy will be crucial; we demonstrate that, using template matching, molecular detection S/N remains high at $R \geq 2000$. Photometric time series observations of a Jupiter-twin exoplanet can, in principle, allow the detection of Mars-sized exomoons in broadband visible light at distances less than 5pc, and for planets and exomoons closer to their stars and with higher albedos, exomoons that are smaller or further from the Solar System may be detectable. Constraining the occurrence rates of exomoons around gas giants will further test planet and moon formation theories, and any exomoons that are discovered may themselves be candidates for biosignature investigations.

A deep look with Keck Planet Imager and Characterizer (KPIC): Isotopologue measurements for HR 7672 B
Ben Andrew Sappey (UC San Diego)

Keck Planet Imager and Characterizer (KPIC), the upgrade to the high-resolution NIRSPEC spectrograph on Keck-II, has been extremely successful at characterizing the atmospheres of close separation exoplanets, brown dwarfs, and ultra-hot Jupiters at high spectral resolution (R=35,000). This high spectral resolution allows us to probe complex atmospheres, resolving individual molecular absorption features. With sufficiently high SNR data (i.e., cross-correlation peak >20), we

can even detect trace species such as isotopologues like 13CO. The ratio between isotopologues, e.g. 12CO/13CO, potentially serves as an indicator of companion formation location through the fractionation of the protoplanetary disk for exoplanets, while products of binary star formation is expected to produce stellar isotopologue ratios. An excellent test case of making isotopologue ratio measurements with KPIC is HR 7672 B, a brown dwarf with a measured dynamical mass (72.9 $\pm$0.8 Jupiter masses; Brandt et al. 2019), a relatively bright K-band magnitude of 13.04 $\pm$ 0.10 (Boccaletti et al. 2003), and 9 epochs of data totaling 14h 54min on this single target (see Ruffio et al. 2023). We use a combinatory likelihood strategy within the code breads to combine epochs of data in a statistically robust way, increasing the SNR of the crosscorrelation of the spectra with atmospheric templates. We present atmospheric analysis with the retrieval code petitRADTRANS to update properties and give estimates of isotopologues in the atmosphere of HR 7672 B.

A Conceptual Exploration of High-Contrast Aperture Masking Interferometry
Benjamin Calvin (UCLA)

The search for the direct discovery and characterization of Earth-like exoplanets has motivated high contrast imaging surveys using coronagraphs with narrow inner working angles. These observations typically search for companions at angular separations of >2 lambda/D. Traditional imaging methods, however, are limited by the size of the on-axis PSF and are not sensitive to closer-in companions. Meanwhile, non-redundant masking (NRM) techniques have been used with single-aperture telescopes to interferometrically resolve astrophysical features at angular scales within the diffraction limit, but NRM interferometry faces sensitivity issues for features that are not of comparable brightness. In this project, we investigate utilizing high contrast coronagraphy in conjunction with NRM interferometry. While the targets of interest for the NRM are within the typical inner working angle of the coronagraph, a vortex coronagraph - centered on a stable, high-Strehl PSF - will still deliver an improvement in the relative throughput of the faint companion, which will improve the sensitivity of the interferometric observables. The goal of this preliminary investigation is to introduce the conceptual architecture for combining these two techniques and to explore the potential discovery space for high contrast targets within the inner working angle of traditional high contrast imaging.

Measuring Worlds by Their Lines: Unlocking High-Dispersion Coronagraphy in H-band at VLT with HiRISE
Bhavesh Rajpoot (Max Planck Institute for Astronomy)

Characterizing directly imaged exoplanets by accessing their intrinsic spectra gives us an edge in examining their properties while minimizing host contamination. Over the past two decades, discoveries made through high-contrast imaging (HCI) have shown a bias toward detecting intrinsically hot, low-gravity companions in wide orbits, typically around nearby, young, rapidly rotating, and often active host stars. HCI also limits characterization of companions at low resolution until high-resolution spectroscopy (HRS) is employed, which presents its own challenges. The High-Resolution Imaging and Spectroscopy of Exoplanets (HiRISE) instrument at the Very Large Telescope (VLT) integrates SPHERE's HCI capabilities with CRIRES+'s HRS prowess to implement high-dispersion coronagraphy (HDC). This integration is achieved through a single-mode fiber-coupling mechanism utilizing dedicated injection/extraction modules and a telescope fiber relay, delivering H-band spectroscopy at R=140,000. Within this landscape, HiRISE enhances the global HDC effort by achieving H-band, R=140,000 performance complementary to Keck/KPIC (K–L, R=35,000) and Subaru/SCExAO-REACH (Y–H, R=70,000); together, these systems span wavelength, resolving power, and sky coverage, while HiRISE improves line contrast and kinematic sensitivity at shorter near-IR wavelengths. Our ongoing HiRISE survey targets more than 35 known directly imaged substellar companions that are newly accessible to high-resolution spectroscopy via fiber-fed HDC. The sample spans a wide range of companion masses and separations, and ages from a few Myr to several Gyr, to enable population-level tests. This contribution will report the survey design, target selection rationale, operations and calibration workflow, and the analysis pipeline for planet radial velocities and projected rotation extraction, and outline comparative strategies for multi-companion systems. I will also discuss forward-looking avenues—such as time-resolved line profiles as probes of planet-centric dynamics and longer-term sensitivity pathways to detect circumplanetary disks or exomoon signatures.

Analytical Karhunen-Loève Data Imputation for RDI and ADI/SDI Scenarios
Bin Ren (Observatoire de la Cote d'Azur)

While machine learning methods have enabled the discovery of directly imaged exoplanets in archival datasets, their iterative nature is computationally intense and the results are subject to regularization terms. In comparison, the Karhunen-Loève image projection (KLIP) has been an analytical and classic approach in high-contrast imaging data reduction. However, KLIP encounters over-fitting and self-subtraction in RDI, ADI, and SDI datasets. On the one hand, to strategically avoid KLIP over-fitting, we can partition the regions of image matrices in RDI observations. On the other hand, for self-subtraction, we can mask and permute selected regions of image matrices in ADI and SDI datasets. These partition and permutation approaches strategically enable analytical (i.e., non-iterative) Karhunen-Loève data imputation in the post-processing of high-contrast imaging datasets.

Apodized Pupil Lyot Coronagraphs for the Habitable Worlds Observatory
Bryony Francesca Nickson (Space Telescope Science Institute)

The Habitable Worlds Observatory (HWO) will require high-performance coronagraphs to achieve the level of starlight suppression necessary for direct imaging and characterization of Earth-like exoplanets. The Apodized Pupil Lyot Coronagraph (APLC) is a promising approach, offering compatibility with obscured and segmented apertures, as well as the flexibility to optimize design parameters, such as the inner working angle, to maximize scientific yield. In this work, we present APLC solutions for the HWO Exploratory Analysis Cases (EACs) 1, 2, and 3. Utilizing the open-source aplc-optimization package, we generate a suite of apodizer and Lyot stop configurations, evaluating their performance in terms of throughput, inner working angle, contrast, and sensitivity to aberrations. We compare performance trade-offs between the apertures and highlight sensitivities to pupil features, such as segment gap size, strut width, and on-axis versus off-axis geometry. Finally, we present a preliminary assessment of the expected exoplanet yields for these designs.

First laboratory demonstration of iEFC for high-contrast imaging at small angular separation on ELT scales
Charles Sallard (Observatoire de la Côte d'Azur (OCA))

Implicit Electric Field Conjugation (iEFC) is an efficient, model-free wavefront control (WFC) technique for dark-hole creation and maintenance. Its model-free nature, not based on a synthetic model of the instrument but on calibration with real data, makes it uniquely versatile and attractive. iEFC has been successfully demonstrated in a variety of environments, both in the laboratory and on-sky, with different setups and coronagraphs. In these tests, the resulting dark holes have generally featured large or moderate inner working angles (IWA) and wide fields of view (FoV), spanning several tens of λ/D. Here, we report the first demonstration of iEFC at small angular separations, achieving a dark hole from 1 λ/D to 4 λ/D on a segmented pupil in the H band under laboratory conditions. This combination of an aggressive IWA with a reduced FoV highlights the uniqueness of the SPEED facility (Segmented Pupil Experiment for Exoplanet Detection). SPEED is a coronagraphic testbed designed for ELT-like segmented telescopes, developed in the context of the ESO Extremely Large Telescope's PCS instrument (Planetary Camera and Spectrograph). Its reflective PIAACMC (Phase-Induced Amplitude Apodization Complex Mask Coronagraph) and its multi– and out-of–pupil-plane DM architecture are specifically optimized for generating compact dark holes at very small IWAs. Our results demonstrate the potential of iEFC, when combined with SPEED's WFC design choices, to ideally push the limits of high-contrast imaging down to 10^{-7} contrast in the dark hole. Ultimately, this progress paves the road to meeting the stringent high-contrast requirements of ELT-class instruments, opening new opportunities for exoplanet detection at unprecedented angular resolutions.

Protoplanets Revealed by Spiral Motion from SAFFRON: Candidate Drivers of Spirals and Gaps in SAO 206462 and V1247 Ori Disks
Chen Xie (Johns Hopkins University)

At the early stages of planet formation, giant planets interact with their surrounding environments and leave observable signatures on protoplanetary disks. Spiral arms in protoplanetary disks are among the most striking substructures revealed by high-contrast imaging. Hydrodynamical models show that such spirals can be driven by planetary companions, yet no spiral-arm-driving protoplanet has been unambiguously confirmed. By observing spiral systems at multiple epochs and measuring their motions, we can distinguish between companion-driven spirals, which co-rotate with their drivers, and alternative mechanisms such as gravitational instability, which follow local Keplerian motion. To address this systematically, we have initiated the Spiral Arm Formation From mOtion aNalysis (SAFFRON) survey, a dedicated VLT/SPHERE program targeting 37 spiral-hosting disks in polarized light. SAFFRON provides an 8.2 ± 1.4 yr baseline, enabling spiral pattern speeds to be measured at $>5\sigma$ and dynamically mapping the orbits of potential companions. This approach offers a new pathway to constrain the occurrence rate and orbital distribution of protoplanets. I will present preliminary results from two benchmark systems, SAO 206462 and V1247 Ori, where spiral-arm-driving companions are dynamically inferred and predicted to reside within ALMA disk gaps. For SAO 206462, three epochs of SPHERE imaging spanning seven years constrain the spiral pattern speed to $-0.85 \pm 0.05^{\circ}$ yr^{-1}, consistent with a single protoplanet on a circular orbit at 66 ± 3 au. For V1247 Ori, the two-epoch data indicate a driver at 118 ± 20 au (0.29" $\pm$ 0.05"). In V1247 Ori, the inferred orbit also coincides with a Keck/NIRC2 planetary-mass candidate. These results illustrate how SAFFRON can systematically uncover the "missing" spiral-arm-driving planets. Upcoming JWST/NIRCam observations of V1247 Ori will provide a decisive test, potentially establishing the first confirmed spiral-arm-driving, gap-opening protoplanet.

Bifurcated Rotation of Giant Planets and Brown Dwarf Companions
Chih-Chun "Dino" Hsu (Northwestern University)

We present a rotational velocity (vsini) survey of 31 targets using Keck/KPIC high-resolution spectroscopy, including 6 giant planets and 21 brown dwarf companions. Adding 12 companions with literature spin measurements, we construct the largest spin sample for 43 benchmark brown dwarf companions and giant planets in this mass range to date. We compare their spins, parameterized as fractional breakup velocities at 10 Myr, assuming constant angular momentum evolution. We find the first clear evidence that giant planets exhibit distinct spins versus low-mass brown dwarf companions at $>3\ \sigma$ significance, assuming inclinations aligned with their orbits, while under randomly oriented inclinations the significance is at $1.5\ \sigma$. The higher fractional breakup velocities of planets can be interpreted as less angular momentum loss through circumplanetary disk breaking during the planet formation phase. The mass ratio at $\sim$0.8%, compared to the companion mass, provides a much cleaner cut for the spins of the giant planets and brown dwarf companions in our sample. We also find that free-floating brown dwarfs show different spins compared to brown dwarf companions. Our results imply that disk braking determines the distinct spins between giant planets and brown dwarf companions at early stages. We thus demonstrate that spins are a promising probe to disentangle the formation of giant planets and brown dwarf companions, along with the upcoming HISPEC and future discoveries of imaged giant planets.

Spectroscopic confirmation of the planet WISPIT 2c
Chloe Ann Lawlor (University of Galway)

WISPIT 2 is a nearby young star with a multi-ringed disk which was recently confirmed to host a 4.9 MJup gas giant planet embedded in a large (60 au) gap at a radial separation of 57 au from the host star. We confirm and characterise a close-in planet in the WISPIT 2 system using a combination of new VLT/SPHERE H-band dual-polarisation imaging and VLTI/GRAVITY K-band interferometric observations of the WISPIT 2 system. The GRAVITY detection is consistent with a point-like source while its extracted K-band spectrum shows CO band-head absorption at 2.3 um and a continuum shape consistent with a young giant planet. From the GRAVITY data we extract a medium resolution K-band spectrum of the companion and fit atmospheric model grids using the species tool with nested sampling to constrain its effective temperature, radius and luminosity. We infer Tef f of 1750-2350 K and a radius of 1.0-1.8 RJup. Comparison with evolutionary tracks implies a mass range of 7-12 MJup, approximately twice as massive as the previously confirmed WISPIT 2b. The astrometry rules out a background source and marginally detects orbital motion of WISPIT 2c, which needs further follow-up observations for confirmation. WISPIT 2 now becomes an analogue to PDS 70, offering a second laboratory for studying the formation and early evolutions of planets within their natal disks.

The Gemini Planet Imager CAL2 upgrade, toward reflected light exoplanet imaging with high-speed focal plane wavefront sensing
Christian Marois (National Research Council of Canada)

The search for exoplanets & debris disks using ground-based telescopes is currently limited by non-common path (NCPA) optical aberrations that generate quasi-static speckles in the coronographic focal plane, whose signal-to-noise ratio increases with integration time and can mask the faint exoplanet light. These speckles are evolving on a wide range of time scales and wavelengths that makes them difficult to calibrate and subtract by various post-processing approaches, such as reference/angular/spectral differential imaging. The National Research Council of Canada has developed a new "CAL" (calibration unit) system for the Gemini Planet Imager 2 (GPI2) instrument based on the self-coherent camera/FAST concept. The system is designed with a near-infrared photon counting camera capable of performing focal plane electric field measurements up to 200Hz, allowing for unprecedented active NCPA speckle corrections, while also enabling high-speed post-processing using the coherent differential imaging technique. CAL2 is expected to dramatically increase GPI2's sensitivity to fainter/lower mass exoplanets at small angular separations, especially on bright stars. I will describe CAL2's final optical/mechanical designs, and show pictures/results of its assembly/testing phases (Fall 2025). The CAL2 instrument integration in GPI2 is planned for early 2026, while first on-sky tests at the Gemini North observatory are expected Fall 2026.

Spatially-Resolved CO Gas and Dust Emission in the disk of AB Aurigae with Gemini/GNIRS HR-IFU and Insights from Commissioning data
Cicero Lu (NSF's NOIRLab/Gemin-N)

AB Aurigae is a young, Class II protoplanetary system showing spiral structures and velocity wiggles indicative of formation of giant planet via gravitational instability. Using Gemini North's new high-resolution GNIRS IFU during commissioning, we mosaicked three M-band (4.9-μm) pointings, on-star and $\pm$0.625" offsets, because the 1.25" $\times$ 1.8" field of view is smaller than the $\sim$4"-diameter disk. The resulting data cube resolves P22, P25 and P26 CO rovibrational lines at R$\sim$19 000, allowing us to map the hot and warm gas and compare it to cold CO kinematics from ALMA. We performed Injection-and-recovery tests with simulated giant planets akin to HR8799 planetary structure and show that even shallow exposures achieve at least 1e-3 contrast. This high-resolution L and M-band capability complements JWST's NIRSpec IFU (R $\approx$ 3000) and can provide new insights into the spatial distribution and dynamics of gas in gravitationally unstable protoplanetaary disks and debris disks.

The Orbital Evolution of Multiple Wide Super-Jupiters: How Disk Migration and Dispersal Shape the Stability of The PDS 70 System
Clarissa R. Do O (Caltech)

Direct imaging has revealed exoplanet systems hosting multiple wide-orbit Super-Jupiters, where planet-planet interactions can shape their long-term dynamical evolution. These strong perturbations may lead to orbital instability, raising questions about the long-term survival of such systems. Shortly after formation, planet-disk interactions can shepherd planets into mean-motion resonances, which may promote long-term stability, as seen in HR 8799. However, early-stage processes such as photoevaporation and disk viscosity can influence these outcomes. The 5 Myr-old PDS 70 system offers a unique laboratory to investigate these processes: its two massive (4 MJup), wide-orbit (>20 AU) giants are still embedded in their natal disk. We perform 2D hydrodynamic simulations of the system, allowing the disk to disperse via photoevaporation. Once the disk dissipates, we continue to track the planets' orbital evolution over Gyr timescales using N-body simulations. We find that the system is likely to remain stable for >1 Gyr. To assess the importance of disk-driven evolution, we compare these results with disk-free N-body simulations using orbital parameters constrained by orbit fits that include recent relative astrometry and radial velocities from the literature. In this case, we find that only <4% of posterior is stable for 100 Myr, highlighting the importance of considering disk-driven evolution for long-term dynamics stability of exoplanetary systems. We also simulate two three-planet configurations including the proposed inner candidate "PDS 70 d", finding that a higher photoevaporation leads the system to become unstable in < 10 Myr.

Comparing Starshade and Sunshade Coronagraphs
Claude Jean Aime (Côte d'Azur University)

This presentation compares solar and stellar coronagraphs employing external occulters—Sunshades (with ASPIICS as a reference) and Starshades. Both systems share the same principle: blocking unwanted light from a bright source before it reaches the telescope. Yet their geometrical and observational domains differ drastically. The apparent angular size of the observed targets spans degrees for the solar corona and milliarcseconds for stellar systems. Consequently, occulter diameters range from meters (1.42 m for ASPIICS) to tens of meters, and occulter–telescope separations from a few hundred meters (145 m for ASPIICS) to several thousand kilometers. Due to very different flux levels, solar observations operate over narrow spectral bands, while Starshades must cover broad wavelength ranges. The key optical distinction arises from the source nature: the Sun and its corona are extended, while stars and exoplanets are point-like. This difference strongly affects scattered light and the optical strategies to control it. Solar coronagraphy benefits from decades of experience with space-based external occulters, from LASCO to ASPIICS—the first to operate in precise formation flight. ASPIICS thus anticipates the technology required for future Starshades capable of directly imaging exo-Earths. ASPIICS combines an external occulter with a Lyot coronagraph; both contribute comparably to straylight suppression. We will also examine the potential advantages of including a coronagraph in starshade-based architectures. Finally, we will discuss how solar and stellar occulter concepts have evolved along different paths. Solar designs have been refined through experimental feedback—serrated rims, multi-disk or conical shapes—while Starshades emerged from theoretical optimization, their petal shapes realizing apodized transmission profiles in practice.

Assessing Exoplanet Habitability with HWO Polarimetry
Connor James Vancil (UCSB)

The upcoming Habitable Worlds Observatory will directly image Earth-like planets and search for signs of habitability. Assessing habitability is a difficult issue, especially when using traditional flux-only (unpolarized) observations. Polarimetry, which takes into account the full informational content of light, is an important tool that will break down degeneracies in the characterization of HWO's target exoplanets. Polarization, arising from scattering particles in the exoplanet's surface and atmosphere, provides important information about the scattering particles sizes, distribution, chemical composition and more. This makes it a powerful tool in assessing a target's atmosphere and surface. Furthermore, polarization can characterize heterogeneities: diurnal rotation, seasonal changes, weather patterns, and other complex, time-dependent signatures that determine a target's habitability. When combined, these factors provide a unique polarimetric signature for each target wherein the degree of polarized light varies as a function of wavelength. In this work, we explore the polarimetric color signatures of different possible exoplanets. Using polarization-sensitive models of planets with varying surface and atmosphere composition in reflected light, we compare their measurable polarization values in broadband optical and near-infrared filters. We compare models of Venus, Jupiter, Mars, and Earth along various epochs of its life to assess the polarimetric signatures of possible HWO targets and look for 2-3 filter combinations that provide the most distinguishing measurements. Using the Python-based coronagraphic exposure time calculator for HWO, peEDITH, we assess the feasibility of these observations and provide tentative observing strategies. The need for a polarimetry mode on HWO has been acknowledged by the community and mentioned in multiple Science Case Development Documents. The results presented herein are part of a large effort advocating for its inclusion in mission design.

Spectral Order Sorting with the Multi-Object MKID Optical Spectrometer (MOMOS)
Crystal Kim (UCSB)

The concept of the echelle spectrometer that uses energy-resolving detectors is more than two decades old. Building on previous conceptual work, we present here the first ever laboratory results of spectral order sorting using a superconducting detector-based hybrid spectrometer. MOMOS (Multi-Object MKID Optical Spectrometer) is a visible wavelength multi-order spectrometer that uses MKIDs (Microwave Kinetic Inductance Detectors). MKIDs lack read noise and dark current enabling noiseless post-observation rebinning and characterization of faint objects like exoplanets and binaries, as well as time-resolved photon-counting spectroscopy. With the ability to resolve energy with an R=E/dE of 7 and above, a linear MKID array takes the place of both the cross disperser and detector in the spectrometer. The echelle grating still disperses the incoming light in the spectral direction, resulting in multiple entangled orders. Each MKID is then capable of separating the spectral orders using a simple, approximately linear relationship between photon energy and MKID phase response.

AstroPIC: Advancing a near-infrared photonic coronagraph toward the Habitable Worlds Observatory
Dan Sirbu (NASA Ames)

The Habitable Worlds Observatory (HWO), identified as the top priority flagship for astrophysics in the 2020 Decadal Survey, requires a coronagraph instrument capable of unprecedented starlight suppression to directly image Earth-like planets. Photonic integrated coronagraphs (PICs) offer unique advantages for this mission by combining the efficiency and aggressive inner working angles of advanced nulling architectures with the compactness and reconfigurability of integrated photonics. The photonic circuit form factor addresses key volume and stability requirements, enabling additional channels and functionalities beyond what is feasible with bulk-optics designs. AstroPIC is a photonic integrated coronagraph that utilizes highly reconfigurable Mach-Zehnder interferometric meshes to adaptively optimize starlight suppression across narrowband spectral channels while providing scalability to larger mode counts. Together, these features open a pathway to enhance HWO's scientific yield and mitigate technical risks by embedding coronagraphic performance within a stable, miniaturized platform. This presentation will provide an overview of both current and planned AstroPIC technology development efforts advancing photonic integrated coronagraphs toward HWO infusion. The small inner working angle and high throughput potential of AstroPIC makes it uniquely well-suited as a near-infrared coroangraph. We will highlight recent laboratory demonstrations, including chip-based nulling that has reached contrasts of 6.3×10^{-10}, and system-level tests coupling free-space light through the HWO pupil into the PIC. We will present design reference mission simulations compatible with current exploratory analytic (EACs 1-3) cases that demonstrate compatibility across segmentation type (keystone or hexagonal), obscuration (on-axis vs off-axis), and illustrating the potential science return when integrated coronagraphs are incorporated. Finally, we highlight results from latest simulations that exploit the reconfigurability of the photonic mesh for broadband optimization, and describe ongoing efforts to extend these demonstrations toward system-relevant bandwidths. Together, these results underscore the promise of photonic coronagraphs as a transformative element in HWO's architecture and exoplanet science case.

Overview and laboratory validation of the front-end instrument (FEI) subsystem of the Keck/HISPEC instrument
Daniel Echeverri (Caltech)

The High-Resolution Infrared Spectrograph for Exoplanet Characterization (HISPEC) is a new instrument for the W. M. Keck Observatory that delivers R$\sim$100,000 fiber-fed spectroscopy across the y, J, H, and K astronomical bands (0.98-2.5μm) simultaneously. The front-end instrument (FEI) subsystem acts as the interface to the facility adaptive optics (AO) system, injecting the AO-corrected light into single-mode fibers (SMFs) that are then routed to the two instrument spectrographs. The FEI builds on heritage from the Keck Planet Imager and Characterizer (KPIC) instrument, with all elements optimized to maximize SMF coupling efficiency . A tracking camera and fast steering mirror are used to keep the light centered on the SMFs, an atmospheric dispersion corrector minimizing chromatic smearing of the PSF, and phase-induced amplitude apodization (PIAA) optics reshape the beam for optimal fiber injection. The FEI also supports various phase masks to enable a fiber nulling mode that extends HISPEC's detection capabilities to <1 λ/D, thereby probing within the inner working angle of conventional coronagraphs. The FEI has now been assembled and validated at the subsystem level in the laboratory at Caltech. Here we present a technical overview of the FEI design, results from validation tests, predicted on-sky performance, and progress on nulling mask acquisition and characterization.

Hybrid PIAA-coronagraphy and -wavefront sensing using a single optical metasurface focal plane mask

Dhwanil Patel (Leiden Observatory, Leiden University)

A major challenge in high-contrast imaging is controlling residual wavefront errors that cause starlight leakage and speckle noise, which can obscure faint exoplanets. These errors arise from effects such as atmospheric turbulence and non-common-path aberrations (NCPA). Suppressing them requires wavefront sensing approaches that operate in the science path to maintain stability while eliminating NCPA. In this work, we investigate the integration of a Zernike wavefront sensor (ZWFS) with a complex-mask coronagraph (PIAACMC), two systems with closely related working principles. A ZWFS employs a complex focal-plane mask (FPM) that imparts a pi/2 phase shift to the core of the Airy pattern, creating a reference beam for wavefront sensing. Similarly, a complex-mask coronagraph applies a pi phase shift, producing destructive interference that suppresses the on-axis light. The tunability of optical metasurfaces can be leveraged to impart these two phase shifts in different spectral bands selectively. We designed a metasurface-based FPM for the MagAO-X instrument that imparts a pi phase shift in H band and a pi/2 phase shift in J band. The mask performance is assessed by measuring coronagraphic contrast and throughput, as well as dynamic range and sensitivity for wavefront sensing. Simulations show the hybrid mask for coronagraphy achieves an inner working angle of 0.6 lambda/D with a throughput of roughly 70% and a contrast of approximately 1e-4 between 1-2 lambda/D. For wavefront sensing, the sensitivity is similar to a classical Zernike wavefront sensor and with a non-linear gradient-descent algorithm-based reconstructor, the dynamic range is roughly 0.7-1.1 radians, depending on the number of iterations of gradient-descent. We will present the end-to-end simulations of this hybrid coronagraph and wavefront sensor and show the first results of the prototype.

Ongoing Developments for WaveDriver, a Laser Guide Star Adaptive Optics System for HWO

Dominic Francisco Sanchez (Lawrence Livermore National Laboratory)

NASA's Habitable Worlds Observatory (HWO) requires a 100x more stable system than JWST to enable its science goals of habitable exoplanet imaging and characterization. WaveDriver is a concept for a laser guide star spacecraft coupled to an adaptive optics (AO) system onboard HWO that would enable HWO to reach it's picometer-level wavefront stability requirements while relaxing other HWO subsystem requirements. At LLNL and UCSC we are revisiting the concept initially proposed by Douglas et al. 2019 to (A) consider more compatible AO system configurations, (B) test the most promising configurations with a goal of demonstrating 10 pm rms wavefront stability over 10 minutes (sigma10), and (C) develop a WaveDriver mission concept based on points 1 and 2. We present results from ongoing developments in each of these areas, including (1) AO control developments, including with Linear Quadratic Gaussian control and machine learning, (2) AO wavefront sensor (WFS) trade study simulations, (3) simulations, fabrication, and testing of a 133-port photonic lantern WFS/spectrograph that would serve as the natural guide star tip/tilt WFS of the LGS system, (4) LLNL lab testing efforts to reach sigma10 with a variety of WFSs, including a Zernike WFS, 3 sided Pyramid WFS, pupil chopping WFS, self-coherent camera, and Shack Hartmann WFS, and (5) mission concept development efforts.

Monitoring accretion lines on Super-Jupiters with phase-resolved echelle spectroscopy: first results of the ENTROPY program

Dorian Demars (University of Virginia)

Giant planets forming in protoplanetary disks have their evolutionary pathways determined by their accretion phase. Yet, their study remains limited by the current sample of embedded accreting planets: PDS 70 b and c, and the new challenger WISPIT 2b. However, wide-orbit planets may serve as proxies for embedded ones: although slightly more massive, they are not limited to the use of AO instruments, which often comes at the cost of spectral resolution. Accretion mechanisms are studied through emission lines (Halpha, Paschen Beta, ...) forming at or near the accretion shock. They have been discovered on a couple dozen wide-orbit Planetary-Mass Companions (PMCs). However, studies often use medium-resolution spectrographs (e.g., MUSE R$\sim$3000), insufficient to resolve the line profiles and probe the gas dynamics. Recent studies have shown that echelle spectrographs (R $\sim$ 50 000) may in fact be used to study bright optical lines, offering a unique opportunity to constrain accretion models and accretion dynamics. We present the results of a monitoring campaign of the Balmer emission lines (Halpha, Hbeta, ...) of Delorme 1 (AB)b, at R$\sim$50,000 with VLT/UVES. The lines are clearly resolved with variable line profiles and fluxes, on days to year timescales. We detect a UV excess, direct tracer of the accretion shock. We find that its Balmer lines are the combination of two components, only one of which is correlated with the UV excess. We discuss implications in the context of magnetospheric accretion and shock-induced emission. Finally, we present the early results of the ENTROPY program (ExoplaNeT accRetion mOnitoring sPectroscopic surveY), consisting of a systematic variability study of Balmer emission lines on 8 PMCs with VLT/UVES. We find different line behaviors depending on the target, where line profile variability observed at timescales of 20 minutes up to a year.

Optical gain three ways: comparing on-sky, real-time wavefront sensor gain calibrations with MagAO-X
Eden McEwen (University of Arizona)

The Pyramid Wavefront Sensor (PyWFS) is commonly used for natural guide star adaptive optics (AO) systems on current large telescopes and is planned for future 30 m class telescopes. The increased sensitivity of the PyWFS enables more accurate wavefront correction at low spatial frequencies compared to the Shack Hartman WFS. However, the PyWFS' finite linear range presents challenges for non common path correction, wavefront reconstruction, and post processing. One source of these challenges, known as the optical gain (OG) effect, is a change in PyWFS response in the presence of correction residuals. This work investigates OG through on sky measurements with MagAO-X, a visible light extreme AO instrument on the 6.5m Magellan Clay telescope. We present a comprehensive set of on-sky measurements of OG, across a wide range of atmospheric seeing recorded during observing with MagAO-X. Each measurement captures OG through three techniques: 1) An on-sky calibration that acquires OG per spatial mode, 2) realtime measurements of the instantaneous Strehl Ratio (SR) on the pyramid tip, and 3) realtime measurement of known, high-frequency probe signal on the WFS itself. Throughout all measurements, we identify a relationship with variation in AO performance following seeing, and find on-sky OG approximately flat vs mode index. We compare these on-sky results against an instantaneous error budget that demonstrates the same OG behaviors. Our conclusions are that OG is given by the instantaneous SR at the Pyramid tip and OG is approximately flat with spatial frequency. A modally flat OG that follows SR implies that OG can be tracked and accounted for with a high speed focal plane camera.

They may be tiny but they are mighty: Nano-printing coronagraphs for high-contrast imaging
Elena Tonucci (Leiden Observatory)

Imaging Earth-like planets in the habitable zones of their host star is among the main science objectives of future ground and space-based observatories. However, the extreme contrast and small separations needed to image such planets cannot be reached with current technology. A promising technique to reach this goal is coronagraphy with the Phase-Induced Amplitude Apodization Complex Mask Coronagraph (PIAACMC). PIAACMC uses a set of aspheric lenses to apodize the entrance pupil without losses and a phase-shifting focal plane mask for the suppression. The lossless apodization allows us to maintain high throughput and achieve a small inner-working angle, unlocking the capability to search for planets at the diffraction limit. The masks are manufactured in-house at Leiden University with Nanoscribe, a micro-3D-printer that uses two-photon polymerization to achieve submicron precision in height. This manufacturing method allows us to print smooth structures, so, unlike lithography, it is not limited to a small number of etching steps. Future steps include integrating active wavefront sensing and control within the coronagraph through the Self-Coherent Camera (SCC), which will allow for further stellar speckles suppression. In this talk, I will discuss the design and manufacturing process of the focal plane masks and show results from the PIAACMC lab testing and on-sky observations with MagAO-X, the extreme adaptive optics instrument for the 6.5-meter Magellan Clay telescope at Las Campanas Observatory (Chile). This serves as a demonstration of the PIAACMC capability of observing exoplanets at the diffraction limit.

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pyEDITH: Exposure Time Calculator for the Habitable Worlds Observatory Coronagraph Instrument
Eleonora Alei (NASA GSFC (NPP Fellow))

High-contrast imaging telescopes capable of characterizing habitable terrestrial exoplanets are expected to be operational in the 2040s, with NASA's Habitable Worlds Observatory (HWO) as the flagship mission. HWO will be a large ultraviolet/optical/infrared space telescope with a primary goal of directly imaging and obtaining spectra from at least 25 exo-Earth candidates to search for signs of life. The HWO team is currently exploring multiple architecture options spanning different mirror diameters and instrumental configurations to define a single point design that satisfies the mission objectives. We developed pyEDITH, the official Exposure Time Calculator (ETC) for the HWO coronagraph instrument. This Python-based tool simulates wavelength-dependent exposure times and signal-to-noise ratios (S/N) for direct imaging observations. pyEDITH stands apart as the only available ETC that produces high-fidelity noise estimates by automatically collecting all relevant information on the HWO Exploratory Analytic Cases (EACs) being developed by the HWO Project Office team at NASA GSFC for architecture trade studies. The tool was designed to be accessible to the scientific community at all skill levels for understanding the capabilities and limitations of different HWO architectures for exoplanet analyses. In this contribution, I will describe pyEDITH and how it can be used. I will also provide practical examples of some science cases and architecture trades that could benefit from this tool.

Hybrid Photonic Coronagraphy: Integration and Testing on the SEAL Testbed
Emiel Por (UC Santa Cruz)

Photonic integrated circuits (PICs) can act as high-performance coronagraphs in high-contrast imaging instruments. In this approach, telescope light is coupled into a PIC and propagated through a mesh of Mach-Zehnder interferometers (MZIs), where thermo-optic phase shifters direct starlight into a small set of output channels while suppressing it in others. The nulled channels still transmit planet light, enabling the PIC to function as an optimal coronagraph. However, imperfections in the PIC degrade its performance. We investigate hybrid photonic coronagraphs, which retain a bulk-optic coronagraph upstream of the PIC. By suppressing the vast majority of starlight before injection, the hybrid photonic coronagraph significantly reduces tolerance requirements on its PIC, making it more robust to imperfections in chip fabrication, tuning, and stray light leakage. To evaluate this concept experimentally, we integrate a PIC from the AstroPIC program at NASA Ames Research Center into the UCSC SEAL testbed. Injection is achieved in the focal plane of the telescope using a microlens array aligned to grating couplers on the chip surface. We present the optical, mechanical, and thermal design of the prototype and report initial laboratory measurements of throughput, contrast, and stability, comparing the performance of direct and hybrid injection configurations. These experiments aim to explore the feasibility of hybrid photonic coronagraphy as a pathway for next-generation high-contrast imaging instruments.

Exoplanet Demographics from the Gemini Planet Imager Exoplanet Survey: Giant Planets
Eric Nielsen (New Mexico State University)

We present a new demographics analysis of the full Gemini Planet Imager Exoplanet Survey (GPIES), which was conducted from 2014 to 2019 at Gemini South. With over 500 stars imaged at high contrast and 7 detected planets, GPIES places powerful constraints on the population of giant planets between 10-100 AU from their host star. We discuss updates since our original analysis of demographics from the first 300 GPIES stars, and compare our results to other demographics analyses. We also extend our demographics framework for giant planets to include RV data from the California Legacy Survey (Rosenthal et al. 2021, Fulton et al. 2021) to better constrain the turnover in planet occurrence rate near the snow line. This combined approach has started to map out a more complete demographics picture of giant planets from the edge of the host star out to 100 AU. Looking ahead, we discuss implications for future demographics surveys of giant planets, from Gaia DR4 to GPI2.

SCExAO/CHARIS High-Contrast Integral Field Spectropolartimetry of Protoplanetary Disks around (Sub)Solar-Mass Stars
Erica Ann Dykes (University of Texas at San Antonio)

Extreme adaptive optics platforms have enabled precise imaging of protoplanetary disks in numerous systems in the near infrared in the last decade. These observations have discovered a wide range of disk morphologies and lead to significant advances in our understanding of the planet formation environment, but have largely remained skewed to more massive, brighter systems by technological limitations. This has severely limited our understanding of the protoplanetary disks around less massive T Tauri stars in nearby star forming regions. As part of the recent AO3K upgrade, a Near Infrared Pyramid Wavefront Sensor (NIRPyrWFS) has been installed on the 8.2m Subaru Telescope, enabling sensing for extreme adaptive optics corrections in H-band. This allows for optically faint, NIR bright (¿ 10 H mag) systems to be imaged by CHARIS, the only polarimetry enabled high contrast integral field spectrograph currently operating, for the first time. These JHK passband observations in simultaneous total and polarized intensity, yield spatially-resolved imaging, polarization spectra, and polarization fraction measurements allowing us to analyze disk geometry and dust properties. We present preliminary results and analysis for a small sample of (sub)solar-mass stars in nearby star forming regions.

Preparing for First Light - The Mid-infrared ELT Imager and Spectrograph of the Extremely Large Telescope
Gael Chauvin (MPIA)

The Mid-infrared ELT Imager and Spectrograph (METIS) is a first-generation, multi-purpose instrument for the Extremely Large Telescope (ELT), designed to explore the universe with unprecedented sensitivity and precision. By 2030, METIS will deliver diffraction-limited imaging, low- and medium-resolution slit spectroscopy, and coronagraphy for high-contrast imaging between 3 and 13 microns, as well as high-resolution integral field spectroscopy between 3 and 5 microns, enabling transformative science across a wide range of astrophysical domains. In the framework of the ESO instrumentation roadmap, this talk, on behalf of the METIS consortium, will present the instrument's development organization and status, schedule, observing modes, and primary science drivers, spanning topics from Solar System bodies to active galactic nuclei and black holes. The talk will provide a preview of the first science programs, including target selection and initial simulations developed in the context of the preparation of the exploitation of the guaranteed time observations, and highlight how METIS will combine cutting-edge mid-infrared capabilities with advanced observing techniques to pave the way for future discoveries. Special focus will be given to circumstellar disks and exoplanets: from probing the chemistry, kinematics, and dust properties of protoplanetary disks down to the snowline, to characterizing protoplanets, circumplanetary disks, and giant planets and potentially rocky worlds at different evolutionary stages, in synergy with other observational methods. In the coming decade, METIS is expected to open new frontiers for ground-based astronomy and to be transformative in advancing our understanding of planetary formation and exoplanetary science.

Performance Simulations of Photonic-Enabled ExoPlanet Spectroscopic Sensor (PEEPSS) for HWO
Genevieve Markees (University of Central Florida)

The next few years will be critical for technology development for Habitable Worlds Observatory (HWO) in its mission to search for and characterize extrasolar planets. To achieve its stated goals with contrasts of 1 part in ten billion, HWO will require outstanding stability and precision, particularly in measuring and controlling the wavefront of the light propagate through the telescope and coronagraph system. We present simulations for the Photonic-Enabled ExoPlanet Spectroscopic Sensor (PEEPSS), which uses a set of photonic lanterns to efficiently couple light from the "dark hole" in the coronograph focal plane (where the exoplanets are expected to lie) into single-mode fibers and the main spectrograph. PEEPS uses rejected host star light from the region interior to the dark hole to aid in the wavefront sensing; this has the advantage of doing the sensing in the coronograph focal plane, eliminating non-common-path errors between the wavefront sensing and science channels. The photonics lanterns allow us to combine our science channel and wavefront sensor into a single system. PEEPS will be particularly advantageous provide in the near-infrared (NIR) bandpass, which is of particular interest for HWO. Because the limiting inner working angle (IWA) of a coronograph scales as wavelength over diameter, exoplanet imaging in the NIR becomes a major challenge as the IWA can exceed the exoplanet orbital radius. PEEPS will enable NIR coronagraphic observations at smaller IWA than other approaches, increasing the observational parameter space HWO can probe in the search for exoplanets.

Breaking the symmetry: Asymmetric Lyot stops for METIS focal plane wavefront sensing

Gilles Orban de Xivry (University of Liège)

The Mid-infrared ELT Imager and Spectrograph (METIS) will provide high-contrast imaging, including vortex coronagraphy at thermal wavelengths, enabling direct detection and characterization of planets and disks. However, water vapor-induced chromatic turbulence — particularly severe in the N-band — and variable non-common path aberrations are expected to significantly degrade performance and limit companion detectability. To address these challenges, especially the dynamical nature of those turbulence, we developed the Asymmetric Lyot wavefront sensor (ALF). This approach uses an asymmetric Lyot stop to encode even pupil aberration modes into observable intensities, paired with supervised learning to solve the non-linear inversion problem. Our Lyot stop optimization process follows two steps. First, we implement a differentiable instrument model to maximize the Fisher information, optimizing wavefront sensing sensitivity by adapting the asymmetric pattern while minimizing transmission loss. Second, we validate the design using our end-to-end simulation framework, training convolutional neural networks to validate and fine-tune our Lyot stop designs. We present simulations and performance results for selected cases, demonstrating ALF's abilitiy to mitigate dynamical chromatic turbulence. Finally, we discuss on-sky implementation strategies, including reinforcement learning framework for real-time optimization

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Recent characterization results of LmAPDs: towards photon counting infrared arrays for HWO

Guillaume Huber (University of Hawaii)

HWO's objective of performing spectroscopy on Earth-like exoplanets imposes unprecedented demands on detector performance, with each pixel expected to register only a handful of photons per hour. Linear-mode avalanche photodiodes (LmAPDs) are among the leading candidates for the observatory's infrared channel. In recent years, these detectors have achieved negligible dark current and sub-electron effective readout noise, potentially enabling photon-counting operation. In this paper, we present recent progress toward the development of science-grade 1k×1k LmAPDs, highlighting their promise for HWO while also bringing to light new challenges identified through ongoing work. In particular, we focus on issues related to glow and persistence, which must be addressed for future implementation.

Exploring reinforcement learning to enhance METIS focal plane wavefront correction

Iremsu Taskin (ULiege)

High Contrast Imaging (HCI) on ground-based telescopes suffer from phase aberrations on the observed wavefront caused by atmospheric turbulence. Adaptive Optics (AO) systems are adept at correcting these aberrations, but fall short in the correction of non-common path aberrations (NCPAs). NCPAs arise because the wavefront sensor (WFS) measures and corrects a wavefront that is different from that affecting the science images, thus requiring additional intervention. In the past years we have developed focal-plane wavefront sensing (FPWFS) for vortex coronagraphs, exploring various techniques to lift the sign-ambiguity on even Zernike modes and to estimate NCPAs. We have used Deep Learning (DL) algorithms to train models on laboratory datasets of Zernike coefficients which were used to identify and correct aberrations (Quesnel 2024). Here, we move from

DL to Reinforcement Learning (RL) to enable real-time training and correction of NCPAs. We focus on the Mid-infrared ELT Imager and Spectrograph (METIS) and the water vapor seeing that causes significant aberrations on mid-infrared exoplanet observations. We have created a simulation that mimics the METIS instrument, emulates the water vapor-induced aberrations and uses RL to correct disturbed wavefront. Our goal is to optimize these RL algorithms for on-sky demonstrations of this technique, which will be a major milestone for the deployment of FPWFS on METIS.

MAPS – the MMT Adaptive optics exo-Planet characterization System
Jennifer Patience (ASU)

The MMT Adaptive optics exoPlanet characterization System (MAPS) is an exoplanet characterization instrument that combines an upgraded adaptive optics system and a high resolution infrared spectrograph. MAPS will perform observations to measure the composition and physical characteristics of exoplanets with in transiting orbits, and wide-orbit companions identified by direct imaging. The MAPS spectral coverage will provide a single snapshot observation covering 1 to 5 micron at a high spectral resolution R=45,000; the Y-K range can be recorded simultaneously with sections of L and M. The MAPS AO system has two pyramid wavefront sensors, one sensitive to the optical and one sensitive to the infrared, which will enable the system to lock on obscured or faint guide stars. The wavefront sensors incorporate two state-of-the-art detectors than can be used to optimize the AO correction for a broad range of targets, with the control loop operating at up to a 1 kHz rate. The 6.5m MMT telescope will have an upgraded adaptive secondary mirror with 336 actuators to improve the performance while preserving the desired low backgrounds for long wavelength observations. With the completed MAPS instrument, a 60-night science program has been allocated to characterize the atmospheric composition and dynamics of a sample of exoplanets. The AO system has achieved first-light and optimization and characterization of the system is ongoing.

Discovery of H Emission from a Protoplanet Candidate Around the Young Star 2MASS J16120668-3010270 with MagAO-X
Jialin Li (University of Arizona)

2MASS J16120668-3010270 (hereafter 2MJ1612) is a young M0 star that hosts a protoplanetary disk in the Upper Scorpius star-forming region. Recent ALMA observations of 2MJ1612 show a mildly inclined disk (i=37) with a large dust-depleted gap (Rcav=0.4" or 53 au). We present high-contrast H observations from MagAO-X on the 6.5m Magellan Telescope and new high resolution sub-mm dust continuum observations with ALMA of 2MJ1612. On both 2025 April 13 and 16, we recovered a point source with H excess with SNR 5 within the disk gap in our MagAO-X Angular and Spectral Differential (ASDI) images at a separation of 141.962.10 mas (23.450.29 au deprojected) from the star and position angle (PA) = 159.000.55. Furthermore, this H source is within close proximity to a K band point source in SPHERE/IRDIS observation taken in 2023 July 21 (Ginski et al. 2025). The astrometric offset between the K band and Hα source can be explained by orbital motion of a bound companion. Thus our observations can be best explained by the discovery of a $\sim$4 MJup accreting protoplanet, 2MJ1612 b, with measured H line flux of (29.7 7.5)x10-16 ergs/s/cm2 and (8.23.4)x10-16 ergs/s/cm2 between 2 observational epochs. 2MJ1612 b is likely the third example of an accreting Hα protoplanet responsible for carving the gap in its host disk, joining PDS 70b and c. Further study is necessary to confirm and characterize this protoplanet candidate and to identify any additional protoplanets that may also play a role in shaping the gap.

Developing Optical Models of Coronagraphic Testbeds at JPL
John Krist (Jet Propulsion Laboratory)

The Jet Propulsion Laboratory has been conducting experiments with coronagraphic and wavefront control techniques for over 25 years with facilities such as the High Contrast Imaging Testbed (HCIT) that serve both internal and external (NASA SAT proposals) studies, as well as the Roman coronagraph. A variety of coronagraphs and deformable mirrors have been evaluated on multiple benches, both in-vacuum (DST1, DST2, OMC) and in-air (IACT). One of these will transition to become a testbed (EPIC5) for early demonstration of Habitable Worlds Observatory technologies. Full optical models of these facilities, incorporating measured properties of the optics, have only recently been initiated, starting with DST1 and DST2. The development of these models, including dealing with unknowns in testbeds built a decade ago, will be discussed along with how the models are used to investigate the impact of defects, wavefront control parameters, and contrast limits.

A demonstration of low order wavefront sensing and control for HWO exoplanet imaging
John Trauger (JPL / Caltech)

Active stabilization of the HWO optical wavefront is required for HWO exoplanet coronagraphy. The wavefront must be controlled over two distinctly different frequency regimes. Pointing jitter, alignment drift, and thermal gradients across large structures require active maintenance for even the most stable space observatory, while the coronagraph must passively maintain the deformable mirror settings responsible for high contrast over times comparable to science observations. We describe a new optical element designed specifically for the stabilization of low-order wavefront errors and minimization of disturbances to the coronagraph. Performance of this element is measured in a vacuum interferometer, then integrated into a vacuum testbed to test model predictions and performance in a high-contrast coronagraph.

The Programmable Liquid-crystal Active Coronagraphic Imager for the 4-m DAG telescope (PLACID) instrument: Status Update
Jonas G Kuhn (UNIVERSITY OF BERN)

The Programmable Liquid-crystal Active Coronagraphic Imager for the 4-m DAG telescope (PLACID) instrument is a new high-contrast direct imaging facility that was installed on the Turkish National Observatory in early 2025, with Assembly, Integration and Validation (AIV) activities currently ongoing at the site. The PLACID exoplanet imager is a coronagraphic stage instrument, located in-between the TROIA extreme adaptive optics (XAO) system and the DIRAC HAWAII-1RG focal-plane array. Both the pyramid-based TROIA XAO system, incorporating a 468-DM from ALPAO, and the DIRAC camera were installed on the Nasmyth platform over the fall of 2025, enabling the PLACID team to start commissioning activities over the new year period. Once on-sky, PLACID will be the world's first "programmable active coronagraph" direct imaging platform, fielding a customized spatial light modulator (SLM) acting as a programmable focal-plane phase mask (FPM) coronagraph from H- to Ks-band. This will provide observers with a wealth of novel functionalities, among which software-only update of the FPM coronagraph in function of conditions or science requirements. Future available observational features include non-common path aberrations (NCPA) self-calibration with phase-shifting Zernike wavefront sensing, coronagraphic imaging of multiple stars systems compatible with angular differential imaging (ADI), and time-domain coherent differential imaging (CDI). We hereby present the delivered PLACID instrument and its on-site commissioning status, including the first on-sky results if available at the time.

Relaxing stability requirements on HWO by suppressing sensitivity to specific modes
Jordan Israel Diaz (University of California, Santa Cruz)

The Habitable Worlds Observatory (HWO) primary goal of directly imaging 25 Earth-like planets residing in the habitable zone of Sun-like stars requires unprecedented contrast levels of $\sim 10^{-10}$. To accomplish this, HWO will be equipped with a highly sensitive Coronagraphic Instrument (CI), which requires an "ultra-stable" telescope with picometer-level wavefront errors arising from mechanical and thermal sources. In this work, we explore the potential of making the CI more robust by removing sensitivity to specific modes, in particular correlated segment-level aberrations on the primary mirror of the HWO EAC-1 design. We assess the performance and cost of specific mode suppression in terms of planet throughput, contrast as a function of wavefront error, and expected science yield. Additionally, we discuss the prospective of using Photonic Integrated Circuits (PICs) as an enabling technology to apply the removal of specific modes.

Advancing Vector Vortex Coronagraph Technology for the Habitable Worlds Observatory

Jorge Llop-Sayson (JPL)

The vortex coronagraph offers an efficient solution to starlight suppression: it provides high starlight suppression while maintaining excellent throughput for off-axis sources. It also delivers strong robustness to wavefront errors, a critical path to relaxing the telescope stability requirements. The leading approach to fabricate a vortex coronagraph mask relies on liquid crystal polymers (LCPs), producing what is known as the vector vortex coronagraph (VVC). The main limitation of the VVC arises from mask fabrication errors, which result in a contrast floor above the requirements of HWO. Here, we report recent progress at JPL's Microdevices Laboratory (MDL) toward fabricating VVC masks for HWO. Advances have been made in three key areas: (1) chemical formulation of LCPs, (2) ultra-precise thin-layer deposition on optical substrates, and (3) photoalignment of LCPs to form the vortex pattern. Mastering these three aspects of the VVC fabrication is a sine que non condition to producing a VVC mask that meets the HWO requirements.

When PIGSS fly: a Polarimetric InvestiGation of the Self-luminous Substellar companions AF Lep b and HIP 21152 B
Jules Fowler (UC Santa Cruz)

The convective physics that produces large scale cloud features (e.g., Jupiter's bands and spots) while thought to depend on temperature, is still largely unknown, and we present polarimetric data on two new targets (AF Lep b and HIP 21152 B) at different temperatures to begin to build this population. Young exoplanets and brown dwarfs have self-luminous emission that peaks in the infrared. As that emission moves through clouds it is scattered by aerosols (driven by Rayleigh scattering in the visible and Mie scattering in the IR), which polarizes the object's self-luminous emission. However the positive and negative polarized signal from a symmetrical source is perfectly cancelled when integrated over a planet, i.e., a disk-integrated polarimetric observation is representative only of asymmetries in the polarized signature. These asymmetries are caused by non-uniform cloud distributions and hot-spots, oblateness of the object, and circum-planetary disks. This signature is complimentary to direct spectroscopy, as it breaks degeneracies in cloud morphology and cloud grain size that state-of-the-art forward modeling has yet to disentangle. Here we present the first analysis of two half nights of Subaru/SCExAO spectropolarimetric CHARIS data on the companions AF Lep b and HIP 21152 B. We aim to place upper limits at the level of 0.5 - 0.1% disk-integrated degree of linear polarization on these objects, which can definitely rule out large scale cloud structures and place constraints on rotation speeds. We also comment on polarimetric surveys as a low-risk/high-reward strategy; even if the polarimetric information is not utilized, we can still provide updated orbital fits, mass estimates, and CHARIS integral field spectroscopy data on two fascinating companions.

Atmospheric Characterization of Benchmark Brown Dwarf HIP21152B
Julianne Cronin (Northwestern University)

Benchmark brown dwarves can be used to test and refine substellar evolutionary models and chemistry. We have taken high-resolution near-infrared spectra of benchmark brown dwarf HIP21152 B with the Keck Planet Imager and Characterizer KPIC. This brown dwarf has a well-defined age as part of the Hyades cluster and a previously measured dynamical mass of around 24 Mjup. I will present our work on constraining other HIP21152 B parameters including spin, radial velocity, and elemental abundances by jointly fitting the spectra of three nights of observations for five different models.

Toward understanding the emission mechanisms of accreting planets
Jun Hashimoto (Academia Sinica Institute of Astronomy and Astrophysics)

A planetary growth rate, a.k.a., the mass accretion rate, is a fundamental parameter in planet formation, as it determines a planet's final mass. Planetary mass accretion rates have been estimated using hydrogen lines, based on the models originally developed for accreting stars, known as the accretion flow model. Recently, Aoyama et al. (2018) introduced the accretion shock model as an alternative mechanism for hydrogen line emission. However, it remains unclear which model is more appropriate for accreting planets and substellar objects. To address this, we applied both models to archival data consisting of 96 data points from 76 accreting brown dwarfs and very low-mass stars, with masses ranging from approximately 0.02 to 0.1 $M_{\odot}$, to test which model best explains their accreting properties. The results showed that the emission mechanisms of 15 data points are best explained by the shock model, while 55 data points are best explained by the flow model. For the 15 data points explained by the planetary shock model, the shock model estimates up to several times higher mass accretion rates than the flow model. As this trend is more pronounced for planetary mass objects, it is crucial to determine which emission mechanism is dominant in individual planets. We also discuss the physical parameters that determine the emission mechanisms and the variability of line ratios.

Two-stage coronagraph concept for high contrast imaging
Jun Nishikawa (NAOJ)

High contrast imaging is an essential technique for direct observation of terrestrial exoplanets. Two-stage coronagraph would be one of the few solutions for achieving 10^{-11} raw contrast. The first Lyot mask coronagraph will block most of the star light as early as possible before it encounters many optical elements, thus suppressing the overall generation of incoherent scattered light. Thanks to the partial attenuation of light by the first Lyot mask coronagraph, the downstream optical system can be considered to operate with enhanced precision. For example, the phase resolution of the downstream deformable mirror is virtually improved, enabling deeper dark hole digging.

Imaging and characterising forming exoplanets in their birth environment
Justin Latour (University of Liege)

With the ever-growing population of detected exoplanets, the startling variety in planetary configurations remains mostly unexplained. Studying planet formation in young stellar systems is a crucial step to truly understand this great diversity. To this end, the search for protoplanets is crucial; however, only a few of them have been robustly confirmed so far, e.g., two in the PDS70 system, and, very recently, WISPIT2b. HD 135344B presents a protoplanetary disk with spiral arms and a large cavity depleted of gas and dust. These structures may be due to interactions with an embedded companion, which makes HD 135344B a prime target for the search of protoplanets. We conducted a thorough analysis of archival NACO data, along with multiple SPHERE datasets obtained recently with the star-hopping observing mode. While direct imaging generally uses a coronagraph to block the starlight, the star-hopping observations were captured without one to bypass the limitation on the inner-working angle of the coronagraph. These non-coronagraphic non-saturated observations made it possible to reach unprecedented contrasts at small angular separations within the cavity of HD 135344B. Brand new post-processing algorithms were also tested on these observations. While no robust detection has been discovered so far, we identify protoplanet candidate signals and report their significance and photometry. Upper limits on potential planetary companions are also systematically derived within the cavity. Our observations, spanning roughly 10 years, provide a long enough baseline to study the dynamics of the spirals, as a follow-up to previous studies, which suggested the existence of a spiral-driving protoplanet on an orbit that coincides with a dust filament observed with ALMA. Our analysis of an already previously detected kink in scattered light confirmed that its motion can be linked to this hypothetical spiral-driving protoplanet, adding yet another hint of its existence.

Resolving Tensions Around a Rare Multi-Planet System (HR 8799): An Investigation of Planet Masses and the Search for a Hidden 5th Planet
Kaitlyn Hessel (University of Victoria)

HR 8799 was first directly imaged in 2008 and stands out as a rare multi-planet system that, after scaling for the brightness of the host star, is a remarkable analog for the outer gas giants in our Solar System. With its well-known 4 Jupiter-mass planets at orbital separations ranging from 15-80 au, HR 8799 has been stable for around 30 million years despite the statistical probability that multi-planet systems at these separations tend to be unstable, living for only 100,000 years before self-destructing. The stability of this system however is highly sensitive to the dynamical masses of the inner planets and recent work reports masses too large to allow for stability. To address this contention in the literature, I have begun exploring the possibility of a 5th inner planet, the most plausible explanation to this contention. My work has begun with the exploration of a Julia-based orbital modeling code called Octofitter where I modeled the orbits of the HR 8799 planets, 51 Eridani b and AF Leporis b in single-planet orbits. Next, I will extend this exploration to the full HR 8799 system and perform a Bayesian analysis to determine whether a 4 or 5-planet system is more probable. Additionally, I will be using data from Hipparcos and Gaia to determine if the stellar perturbation of HR 8799 could be due to 5 planets rather than the accepted 4. This work will allow for better prediction of the accepted 4 HR 8799 planet masses and confirm/disprove candidacy of a 5th inner planet.

Closed-loop Atmospheric Dispersion Correction for High Contrast Imaging with MagAO-X

Katei Twitchell (University of Arizona)

Incoming starlight is refracted as it enters Earth's atmosphere from the vacuum of space. Atmospheric refraction is inherently wavelength-dependent, and this dispersion causes elongation of the broadband PSF of ground-based telescopes. The result is degraded image quality alongside reduced coronagraph light-blocking efficiency, limiting contrast especially at small inner-working angles. An atmospheric dispersion corrector (ADC) is a dispersive optic used to compensate for this effect. Current methods for dispersion compensation use analytical models to anticipate dispersion strength based on telescope zenith angle and site parameters. However, uncertainties in these models lead to over- or under-correction of the true atmospheric dispersion by the ADC. In this work, we present a method that uses diffracted satellite spots in AO-corrected science camera images to measure residual atmospheric dispersion in real-time while scientific observations are ongoing. We have used these real-time measurements to implement closed-loop control of the ADCs on-sky using the Magellan Extreme Adaptive Optics system MagAO-X. Active atmospheric dispersion correction on MagAO-X is a precursor to high-contrast imaging with Extreme AO for the upcoming Extremely Large Telescopes, where high-precision dispersion compensation will be required to achieve the contrasts necessary to image exoplanets in reflected light.

Development of High-Contrast Imaging Technique Based on the Speckle Area Nulling Method

Kenta Yoneta (Tokyo University of Agriculture and Technology)

High-contrast imaging techniques are required to discover Earth-like exoplanets and detect biosignatures. High-contrast imaging techniques consist of a coronagraph, a wavefront sensing and control technique, and a post-processing technique, which respectively suppress stellar diffraction light caused by the telescope pupil, stellar scattered light (speckles) caused by wavefront aberrations, and residual stellar light caused by other factors. We have been developing the speckle area nulling (SAN) method as a wavefront sensing and control technique. In the SAN method, the wavefront shape for suppressing the speckles and generating a dark hole can be calculated by using five focal-plane intensity data measured in synchronization with five wavefront modulations. One of the advantages of the SAN method is that it can calculate wavefront shape without requiring a light propagation model of an optical system. The conventional SAN method can only generate the dark hole in a single side region of the star by using a single wavefront control device, such as a deformable mirror. We have devised the SAN method using two wavefront control devices and succeeded in generating dark holes on both sides of the star by numerical simulation. We have also been developing the coherent differential imaging on speckle area nulling (CDI-SAN) method as a post-processing technique to suppress fast fluctuating speckles that cannot be controlled by conventional wavefront sensing and control techniques. In the CDI-SAN method, five intensity measurements similar to the SAN method are performed with short exposure times, faster than the speckle fluctuations. These measurements are repeated until sufficient photons are obtained. The post-processing using obtained integral intensities can suppress the fluctuating speckles contained within the observed image. In laboratory demonstration, the CDI-SAN method improved the contrast degraded by the speckle fluctuations which were introduced into the dark hole generated by the SAN method.

Active focal-plane phase coronagraphy with a pixelated device: Combining simulations and digital holographic microscopy metrology
Liurong Lin (University of Bern)

Recent advances in high contrast exoplanet imaging instrumentation include the concept of adaptive coronagraphy, where liquid crystal on-silicon (LCoS) spatial light modulator (SLM) panels and digital micro-mirror devices (DMDs) are used as programmable focal plane masks and configurable pupil apodizers, respectively. Adaptive coronagraphy provides observers with real time optimization of the coronagraphic configuration in response to changing observing conditions or science objectives, such as switching between survey and characterization modes, or targeting multiple star systems. However, the use of active programmable devices introduces technical challenges including finite pixel sampling, limited phase resolution, chromaticity linked to the scalar phase response, temporal instabilities, and calibration accuracy, all of which can affect coronagraphic contrast performance. This work investigates the performance of pixelated discrete focal plane phase mask (FPM) coronagraphs as a function of key parameters such as spatial sampling, phase resolution, temporal jitter, and calibration errors. Commonly used FPM designs are studied, including vortices, four quadrant, Roddier and Roddier, and azimuthal cosine phase masks, under both monochromatic and broadband conditions, with and without pupil central obstruction. Performance is evaluated using contrast, throughput, and SNR estimates, with a particular focus on real-world scenarios based on SLMs acting as FPM coronagraphs, such as those implemented on the PLACID instrument for the 4-m DAG telescope. Finally, we combine our study with digital holographic microscopy (DHM) measurements of SLM optical response and phase modulation with sub-nanometer interferometric precision, obtained at various optical magnifications. The acquired DHM data thus enable the study of the phase response at both the sub-pixel scale and the full panel surface. Those DHM wavefront measurements, obtained on visible-range SLM panels, are incorporated into the simulation framework described above to assess and simulate their impact on coronagraphic performance.

Preparing for reflected light exoplanet detection campaigns with ground based platforms
Logan Pearce (University of Michigan)

To directly detect and characterize evolved planetary systems and terrestrial planets, including the detection of potential biosignatures like O2, requires shifting from detecting self-luminous planets to looking for the light they reflect from their host star. To date directly detecting exoplanets in reflected starlight has been out of reach due to the high contrasts ($10^{-7} - 10^{-9}$) and close separations (a few λ/D) required, as well as the need for high performance extreme AO (ExAO) in visible wavelengths. With the Roman spacecraft and ground-based extremely large telescope class, this breakthrough is on the very near horizon. MagAO-X, an ExAO instrument on the Magellan Clay telescope with demonstrated high Strehls in the visible, is planning the first ground-based reflected light observing campaigns in the next few years. We are conducting a robust campaign to identify and characterize the best ground-based reflected light targets to enable maximum efficiency for these and future campaigns for ELTs. We have established the Ground-Based Reflected Light Imaging Planner tool (GRIP, http://getagrip.space) to explore literature orbit solutions for candidates, predict on-sky positions as a function of time, and plan follow-up RV and astrometric observations to improve predictions and streamline observations. In this poster we will present the current state of the database and planned upgrades, show current targets and webapp capabilities, and outline plans for updated orbital parameters. We are seeking collaborators interested in joining this effort.

Applications of scalar metasurface phase masks for high-contrast imaging
Lorenzo Koenig (JPL)

The detection and study of exoplanets has become a major science driver for space telescope missions in the past decades. In particular, direct imaging is considered one of the most promising ways of characterizing Earth-like planets around Sun-like stars. To achieve this science goal, coronagraph technologies need to be improved to achieve deeper contrast, and higher throughput. A particularly promising concept is the vortex coronagraph, combining high throughput with a small inner working angle. The challenge with current vortex phase masks is their vectorial nature, requiring the two polarizations to be split, or reducing the throughput of the system by a factor of 2. An alternative is to use scalar (polarization-independent) phase masks, but these are highly chromatic. We discuss a method to achieve achromatic scalar phase masks using metasurfaces, and present our ongoing efforts of fabricating and testing these masks. First, we discuss a metasurface implementation of a scalar vortex coronagraph with topological charge 6, which is one of the most promising architectures to directly image Earth-like planets. This coronagraph provides a good tradeoff between small inner working angle (IWA), and low sensitivity to low order aberrations. Second, we discuss a phase knife mask based on scalar metasurfaces which, when used in a fiber nulling setup, is capable of detecting sources as close as 0.5lam/D to the star. This architecture is particularly interesting in the near-infrared where the diffraction beam width increases, and where planets that are at the IWA of the coronagraph in the visible will appear within the IWA in the infrared. The phase knife would therefore enable the spectral characterization of close-in planets across a larger wavelength range. We conclude by discussing the next steps needed to advance scalar metasurface phase masks for high-contrast imaging of Earth-like planets.

The Redundant Apodized Pupil coronagraph against the low-wind effect: developments and experimental validation on SCExAO/Subaru
Lucie Leboulleux (CNRS, IPAG)

Direct imaging of exoplanets requires not only achieving but also maintaining extreme high-contrast performance over time, particularly for post-processing methods such as Reference-star Differential Imaging that rely on instrument stability. Future large ground-based telescopes (ELT, GMT, TMT) will face a wide variety of time-varying and quasi-static aberrations, among which the low-wind effect (LWE) is already a limitation for current facilities such as the VLT and Subaru. The LWE induces strong phase discontinuities across the telescope pupil, resulting in degraded Strehl ratio and significant stellar leakage through coronagraphs. Several mitigation strategies are under investigation, including thermal coatings, advanced focal-plane wavefront sensors, and optimized coronagraph designs. In this work, we focus on the Redundant Apodized Pupil (RAP) coronagraph, a novel design that apodizes telescope petals individually, thereby limiting the impact of localized aberrations such as pistons and tip-tilts. We present the on-sky experimental validation of the RAP concept with the Subaru Coronagraphic Extreme Adaptive Optics system (SCExAO). Our results quantify both the contrast performance and the robustness of RAP to LWE-induced aberrations, demonstrating its potential as a promising solution to ensure stable high-contrast imaging for the next generation of giant telescopes.

High-Contrast Imaging at First-Light of the GMT: Using the High Contrast Adaptive Optics Phasing Testbed (HCAT) to develop key adaptive optics components for GMagAO-X
Maggie Kautz (University of Arizona)

GMagAO-X is a first-light visible to NIR extreme adaptive optics (ExAO) high-contrast imaging instrument for the 25.4 m Giant Magellan Telescope. Key components include a holographic dispersed fringe sensor (HDFS) for differential piston sensing and a 21,000 actuator parallel deformable mirror for phasing of the segmented aperture. The HDFS is a single pupil-plane optic that employs holography to interfere the dispersed light from each segment onto different spatial locations in the focal plane to sense and correct differential piston between the segments. This allows for a very high and linear dynamic piston sensing range of approximately ± 10 microns. We built the High Contrast Adaptive optics phasing Testbed (HCAT) in collaboration with GMTO/AURA/NSF to prototype the parallel DM and HDFS and validate the necessary wavefront sensing and control strategies. From 2023 to 2024, HCAT was combined in-lab with MagAO-X, an existing ExAO system built for the 6.5 m Magellan Clay Telescope. The HDFS, specifically, was deployed on-sky within MagAO-X as a differential piston sensor on-sky for the first time. We were able to phase each segment to within $\pm\lambda/11.3$ residual piston WFE (at $\lambda = 800$ nm) of a reference segment and achieved $\sim$50 nm RMS residual piston WFE across the aperture in poor seeing conditions. With new funding as of 2025, future work involves converting HCAT into a dedicated GMagAO-X R&D testbed. This will include assessments of technologies such as implicit electric field conjugation on the GMT pupil and utilizing an unmodulated Pyramid WFS with neural networks to perform the fine phasing ($\sim$5 nm residual piston WFE) after the HDFS.

The ANDES high-resolution spectrograph of the ELT: overview of the high-contrast capabilities for exoplanet observations
Mamadou Mamadou (OCA/Lagrange)

We present ANDES, the Extremely Large Telescope (ELT) high-resolution spectrograph to address a broad range of science cases, including the characterization of the atmosphere of exoplanets. With a first light envisioned in the early 2030s, the instrument baseline features a modular fiber-fed echelle spectrograph with visible and near-infrared ultra-stable spectral arms to provide a simultaneous spectral range of 0.4-1.8um with a spectral resolving power up to 100,000. ANDES also includes a Integral Field Unit (IFU) mode-fed by a single-conjugate adaptive optics (SCAO) module and an insertable coronagraph (CORO) module, enabling the combination of high-contrast imaging and high-dispersion spectroscopy (100,000) for the study of exoplanet properties. In this contribution, we introduce the ANDES design and the main features of its spectro-imager mode to probe exoplanet atmospheres at high-spatial resolution and with unprecedented angular resolution. We will present the preliminary results on the predicted contrast and the expected detection performance to determine the yield of exoplanets that will be detected in emitted and possibly reflected light. The characterization operation of the instrument will be discussed to assess the ANDES ability to detect atomic and molecular signatures connected to the exoplanet atmosphere characteristics. Finally, we will review the synergies between ANDES and the other ELT facilities in the characterization of planetary atmospheres at high and low spectral resolution in the next decade.

The Companions to B and A Stars Snapshot (C-BASS) Survey: Discovery of a New Brown Dwarf Companion around an A-Star
Marah Brinjikji (University of Notre Dame)

I present results confirming the discovery of a new substellar companion to an A star from the Companions to B and A Stars Snapshot (C-BASS) Survey, an ongoing high-resolution demographics search for low-mass companions around nearby B and A stars using adaptive optics imaging with NIRC2 on the Keck II telescope. This survey allows for identification and characterization of brown dwarfs in the intermediate stages of evolution. Companions detected through this study will provide a critical comparison to directly imaged star–planet systems and their atmospheres. The goal of the survey is to measure the demographics of brown dwarf companions to intermediate mass stars and expand the number of confirmed companion brown dwarfs. With a sample of wide-separation brown dwarf and low-mass stellar companions, we can quantify the location of the break between star and planet formation and determine the differences between star–star, star–brown dwarf, and star–planet binaries. From a companion search around over 200 young B and A stars within 200 pc, we confirmed one bound companion with photometry consistent with a brown dwarf, as well as 16 bound stellar companions and one white dwarf companion. I will discuss results from the characterization of the new brown dwarf companion using high-contrast adaptive optics Keck/NIRC2 K-band direct imaging and Gemini-North/GNIRS spectroscopy.

Compact high-contrast imaging in high spectral resolution with nulling interferometry and photonics
Marc-Antoine Martinod (Laboratoire Lagrange, Observatoire de la Cote d'azur, Universite Nice Cote d'Azur)

Characterisation of exoplanets and finding biosignatures are among the hottest topics in astronomy. This quest is challenged by the brightness contrast between the faint planet and the overwhelming glare of the host star, their angular separation and the observing conditions degraded by optical aberrations (from the atmosphere or the observatory). Nulling interferometry is a promising technique for this goal by fulfilling both high contrast and high angular resolution requirements. However, it requires a highly stable wavefront to suppress the starlight by destructive interference. Such a combination is often performed by deformable mirrors and mechanical delay lines. Aiming for a spectral broadband extinction is even more challenging as we need to phase wavefronts in every spectral channel. Photonic-Integrated Circuits is a flexible and powerful platform to tackle all these challenges: it provides the flexibility and the compactness in the design to address each of these issues and provide scalable and space-compatible solutions. With the PHOTONICS project, we aim to create novel coherent combination architectures, based on a multimode interferometer coupler, on-chip active phase control with no moving parts to unlock an efficient and broadband starlight suppression. We are also developing an arrayed waveguide grating to perform high-resolution spectroscopy on the planet signal. In this presentation, we present the concept of the combination, how we process the light to obtain a signal robust against stochastic noise and how we manage to make achromatic destructive interference.

High Order Keck Adaptive Optics: Results from lab integration and testing of the High Order Deformable Mirror

Maria Vincent (Institute for Astronomy, University of Hawai'i)

The High Order Advanced Keck Adaptive Optics (HAKA) upgrade will lower residual wavefront error on the Keck II telescope, and enable detailed characterization of older exoplanets, protoplanetary disks, and stars near the Galactic Center. HAKA replaces the original Xinetics deformable mirror (DM) with an ALPAO DM containing magnetic voice coil actuators, and includes upgrading the Shack–Hartmann wavefront sensor (WFS) and implementing advanced wavefront-control algorithms.The new DM arrived in summer 2025 and has completed site-acceptance testing, preparing for lab closed-loop operation and on-sky commissioning in early 2026. We present the test-bench design and alignment, the closed-loop WFS setup, modular lab control software, and results from site-acceptance and closed-loop tests. The lab software includes the ALPAO software development kit (SDK) integrated with a remote-procedure-call (RPC) link to a Zygo interferometer for acceptance testings, and a modular Python interface to the real-time controller (RTC) for tests with the WFS. Our final results prior to on-sky commissioning on the Keck II AO bench include DM laboratory performance metrics and closed-loop stability.

Toward Science-Ready Data: Development and Validation of the Roman Coronagraph Data Reduction Pipeline

Marie Ygouf (Jet Propulsion Laboratory)

The Nancy Grace Roman Space Telescope Coronagraph Instrument will demonstrate space-based high-contrast imaging at visible wavelengths, opening new opportunities for exoplanet and disk science. To enable these observations, a dedicated data reduction pipeline (DRP) is under development to deliver calibrated, science-ready data products to the community. We present the current development status of the Roman Coronagraph DRP, which is being designed to address the unique challenges of this high-contrast imaging instrument. The pipeline will support multiple observing modes and apply comprehensive calibration and post-processing techniques, including speckle subtraction and data analysis. It will deliver calibrated and PSF-subtracted coronagraphic images, and associated data products suitable for both exoplanet characterization and disk science. This poster will provide an overview of the DRP architecture, highlight recent progress in algorithm development and validation on simulated and testbed data, and outline plans for community involvement and future releases. The DRP will provide a foundation for the community to exploit Roman Coronagraph observations and guide future high-contrast imaging efforts.

Rock Steady: the Habitable Worlds Observatory and its Coronagraph Instrument

Martin Charles Noecker (NASA JPL/Caltech)

The Habitable Worlds Observatory is a NASA mission concept now in Pre-Phase-A study. It was a key recommendation of the AstrO2020 decadal review, with a goal of launching in the early 2040s. It will be able to detect and spectrally characterize Earth-sized planets orbiting nearby stars, and its ultra-stable telescope will also enable a broad range of transformational astrophysics in visible, near UV, and near IR wavelengths. We will describe the coronagraph and observatory designs now being studied, and outline the technical challenges and the path to mission formulation.

Updated Report on High-Contrast Imaging Discoveries and Spectroscopic Characterizations of Brown Dwarfs with the Subaru Telescope

Masayuki Kuzuhara (Astrobiology Center of NINS)

The adaptive optics (AO) system of the Subaru Telescope is under continuous development, enabling new discoveries and detailed characterizations of brown dwarfs (BDs). This effort facilitates not only imaging but also low- to high-dispersion spectroscopy. Our recent high-contrast imaging survey targeting Sun-like stars with astrometric acceleration measured by Hipparcos-Gaia has led to the discovery of a high-mass BD orbiting a nearby G-type star (Kuzuhara et al., in prep.). We also observed the nearby low-mass M dwarf LSPMJ1446+4633 using the high-resolution spectrograph IRD (R $>$ 70,000) in combination with Keck/NIRC2 (Uyama et al. 2025). The radial velocities of LSPMJ1446+4633 measured with IRD, combined with high-contrast imaging from Keck/NIRC2 and Gaia acceleration data, enabled the detection of a BD with a dynamical mass of approximately 60 times the mass of Jupiter. In addition to the above discoveries, we have also conducted spectroscopic characterizations of BDs using the Subaru AO systems and IRD. Initially, our observations with IRD and the conventional AO system AO188 allowed for probing the atmosphere of the T-type BD GL 229B (Kawashima et al. 2025). Our IRD data provided evidence for GL 229B being a binary even from a single-spectrum atmospheric retrieval, consistent with recent AO observations from other facilities. Furthermore, we recently demonstrated the capability of the REACH system for characterizing substellar companions. Using REACH, we combined the extreme AO system SCExAO with IRD and observed the nearby Sun-like star HR 7672 to characterize its BD companion HR 7672B (Kasagi et al. 2025). The REACH observations helped reveal properties of clouds in HR 7672B's atmosphere. These new results stand as important benchmarks for understanding substellar companions, including giant planets, in the era of Gaia DR4 and the Roman Coronagraph. Here, we highlight these scientific achievements recently enabled by the Subaru Telescope's AO capabilities.

A Phase-Shifted Zernike Wavefront Sensor-Based Second Adaptive Optics Stage for PAPYRUS at the Observatoire de Haute Provence.
Mathieu Motte (Laboratoire d'Astrophysique de Marseille/ONERA)

PAPYRUS is an on-sky adaptive optics (AO) platform jointly developed by LAM and ONERA at the 1.52 m telescope of the Observatoire de Haute-Provence. Operational since 2022, its primary goal is to further AO technology developments for the High-Contrast Imaging (HCI) scientific community. To reach the desired contrast for characterisation of Earth-like planets, AO systems must achieve extreme performance. The performance of such systems is principally limited by temporal error. To mitigate it, the AO control loop needs to run faster. This implies a drop in photons per frame, and, consequently, in SNR on the wavefront sensor (WFS) camera. The use of more sensitive WFSs is therefore required but their reduced dynamic range makes it challenging to directly correct atmospheric turbulence. A potential solution is to deploy them in a second AO stage to correct low-order residuals remaining from a first stage. This dual-stage concept is currently being implemented in instruments under development (RISTRETTO, SAXO+, SCExAO). The Zernike WFS (ZWFS) offers sensitivity close to the theoretical limit of Fourier filtering WFSs. To overcome the low dynamic range, the vector WFS (vZWFS) may offer an alternative solution. It doubles the linearity at the expense of a sqrt(2) loss in sensitivity to read-out noise. It is thus a good candidate for a second-stage WFS. To demonstrate such concepts, a second AO stage using a vZWFS was added to PAPYRUS. In this presentation, we will describe the optical design of the second stage. Then, we will detail the characterisation of the components, including the linearity and sensitivity curves of the ZWFS compared to theory. Finally, we will present the first on-sky closed-loop results obtained with a Zernike WFS in a second adaptive optics stage. These results give important insights for the design of future ground-based HCI instruments with eXtreme AO (XAO) systems.

Medium-resolution spectroscopy reveals a carbon-rich circumplanetary disk around the young accreting exoplanet Delorme 1 AB b
Mathilde Malin (STScI / Johns Hopkins University)

Young planetary-mass objects are thought to accrete material from circumplanetary disks (CPDs) of gas and dust. Although such gas is expected to dissipate within the first million years, strong accretion signatures have been observed in older systems, including the 30–45 Myr-old companion Delorme 1 AB b. Using the James Webb Space Telescope's Mid-Infrared Instrument (JWST/MIRI), we obtained a 5–20 μm spectrum of this object. This spectrum confirms the presence of a CPD, with its emission emerging beyond 20 μm. By fitting atmospheric models together with a blackbody component, we refine the properties of the companion's atmosphere and characterize the dust continuum, finding T = 295 +/- 27 K and R = 18.8 +/- 2.7 RJup which implies an inner dust cavity of about 30 RJup. The CPD gas is carbon-rich, showing strong HCN and C2H2 emission and a lack of detectable O-bearing species, consistent with an elevated C/O ratio. In addition, IFU imaging reveals extended H2 emission, indicative of an outflow that may trace a disk wind. These results highlight the persistence of long-lived "Peter Pan" disks, offering new insights into the mechanisms that sustain accretion in evolved, low-mass systems and their implications for planetary system formation and evolution.

Searching for exomoons around Beta Pictoris b and YSES 1b
Matthew Kenworthy (Leiden Observatory)

We present ongoing efforts to search for exomoons around the directly imaged exoplanets Beta Pictoris b and YSES 1b using radial velocity (RV) measurements. Both planets are ideal targets for such studies: their nearly edge-on orbits maximize sensitivity, and high-precision RVs can be obtained with adaptive optics-fed high-resolution spectrographs. If potential exomoons are coplanar with their parent planets, there is also the prospect of detecting the much larger RV signal from the Rossiter–McLaughlin effect. In the case of YSES 1b, ongoing accretion and the presence of a circumplanetary disk further strengthen the likelihood of exomoon formation pathways. We present the first results from RV monitoring of Beta Pictoris b with VLT/CRIRES+ during the 2024/25 observing season. These observations allow us to place upper limits on the occurrence of massive short-period exomoons, excluding the presence of Saturn-mass satellites with orbital periods shorter than five days. We also show that with continued monitoring, sensitivity to Earth-sized moons and analogues to known exomoon candidates will be within reach.

Non-linear low-order wavefront control with a physics-based digital twin: On-sky results from MagAO-X
Matthijs Mars (Leiden University)

Direct imaging of exoplanets using ground-based telescopes requires coronagraphs operating at deep contrast together with precise wavefront control. While state-of-the-art extreme adaptive optic systems remove the majority of wavefront aberrations caused by atmospheric turbulence, residual errors remain causing leakage of starlight and decreasing the coronagraphic performance. Additional aberrations introduced by telescope vibrations and evolving non-common path aberrations (NCPA) further degrade contrast. Some of these errors can be sensed using a low-order wavefront sensor that measures reflected starlight from a reflective focal plane mask or Lyot stop, driving a control loop on a dedicated deformable mirror. In this presentation, I discuss the development of a fully physics-based, differentiable "digital twin" of the focal plane low-order wavefront sensor (FLOWFS) system on the MagAO-X instrument. This model provides accurate forward modelling of wavefront aberrations, allowing us to reconstruct the wavefront errors introduced before or after the reflective focal plane mask using non-linear optimisation. A small calibration set of lab data is used to fit the model to the instrument, after which it is used to derive a linear interaction matrix to correct for low-order correction at 8 kHz. During observation, the model can be updated using non-linear optimisation without disrupting the observation and low-order control loop. Because the digital twin is fully physics-based, it is robust to changing observing conditions and can be easily adapted to different coronagraph configurations or filters with minimal recalibration. I will present on-sky results demonstrating improved low-order stability and enhanced coronagraphic performance from this approach, now integrated into the MagAO-X system. These methods are broadly applicable to other extreme AO platforms and provide a pathway to the robust wavefront control that will be essential for extremely large telescopes.

Progress Towards an Upgraded Detector Array for the MKID Exoplanet Camera (MEC')
Michael Arena (UCSB)

The MKID Exoplanet Camera (MEC), deployed behind the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) instrument in 2018, demonstrated the utility of microwave kinetic inductance detectors (MKIDs) for high-contrast imaging. While MEC has produced a number of science results, including the discovery of several brown dwarf companions, its performance was limited by a number of factors that prevented it from reaching the full scientific promise of a photon-counting detector with intrinsic spectral resolution. Chief among these was the array, which had only 7/10 working feed lines and a pixel yield of 80% on the working feed lines. The spectral resolution of the pixels was also limited by hot phonon escape to be less than R = 10. We report on progress towards fabricating a higher-yield, anti-reflection-coated, phonon-controlled MEC array.

Habitable World Discovery and Characterization: Coronagraph Concept of Operations and Data Post-Processing
Michael McElwain (NASA Goddard)

The discovery and characterization of habitable worlds was the top scientific recommendation of the Astro2020 decadal survey and is a key objective of the Habitable Worlds Observatory. Biosignature identification drives exceedingly challenging observations, which require raw contrasts of roughly 10^{-10} contrast and ultimately, 1-sigma photometric precision of roughly 3x10^{-12} contrast. Despite significant advances for the Nancy Grace Roman Space Telescope's Coronagraph Instrument, technological gaps still exist in a wide range of technologies such as starlight suppression, deformable mirrors, wavefront control, low noise detectors, and high-contrast spectroscopy. Even with these new technologies matured, the Habitable Worlds Observatory must carefully obtain the observations and rely on post-processing of the data to achieve its science objectives. During the START and TAG efforts, a working group was convened to explore the Coronagraph Concept of Operations and Post Processing (COPP) in the context of the Habitable Worlds Observatory. This COPP working group evaluated coronagraphic concept of operations to enable different post processing approaches, such as reference differential imaging and angular differential imaging, polarization differential imaging, orbital differential imaging, coherent differential imaging, spectral processing, and point-spread function subtraction algorithms that incorporate ancillary telemetry and data. Future integrated modeling simulations and testbed demonstrations are needed to determine the achievable post processing gains for each approach. We report a summary of this working group's activities and findings, as well as an outlook for maturation of these techniques and infusion into the Habitable Worlds Observatory technology portfolio.

A New Mid-Infrared Hammer for High Contrast Nails: MIRAC-5+AGPM with MMT-MAPS
Michael R. Meyer (Department of Astronomy, The University of Michigan)

One theme of the Spirit of Lyot conferences since 2007, has been understanding when to use large ground-based adaptive optics-assisted telescopes versus space-based capabilities as a function of angular separation, required contrast, and wavelength. Here we report on MIRAC-5, a 3-13 micron imaging camera utilizing a Geosnap detector, with an annular groove phase mask (AGPM) coronagraph, as utilized with the extreme adaptive optics system MAPS on the 6.5-meter MMT. The Geosnap detector outperforms Si:As blocked-impurity-band detectors operating from 3-13 microns in the high background limit. Further, the measured suppression of host starlight with the APGM developed for MIRAC-5 surpasses that used in the comparable NEAR experiment on the ESO VLT. We should achieve contrast competitive to NEAR from 10-12.5 microns. This capability, to date superior to achieved contrast with MIRI on JWST at 1" in this wavelength range, will open up several gas giant planets for mid-infrared characterization. Such observations can constrain the nitrogen abundance , a key volatile species, through the 10 micron NH3 feature, a critical test of where and when planets form. In addition, improved bolometric luminosities as a function of dynamical mass constraints and system age will provide powerful tests of evolutionary theory in the planetary mass regime. Finally, detecting forming protoplanets embedded in circumstellar disks around young stars at thermal infrared wavelengths will help assess the presence and nature of possible circumplanetary disks. We report on the commissioning of the AGPM, the latest scientific results, and plans for the future of MIRAC-5+AGPM with MMT-MAPS in the era of JWST.

YSES 1 b observations with MagAO-X and updated modeling including circumplanetary disk extinction

Michiel Darcis (SRON / Leiden Observatory)

YSES 1 b is a directly imaged young substellar companion on a wide orbit of 160 AU, making it an interesting challenge for formation theories. Initial photometric observations with SPHERE and NACO from Y to M band suggested physical parameters of Teff=1500 K, R=3 R_J and M=14 M_J. Here, we present new observations in the r', i' and z' band using the MagAO-X instrument and revisit the modelling of YSES 1 b based on the combined MagAO-X, SPHERE and NACO data. In addition, we update the forward model by including the effect of possible dust extinction from the circumplanetary disk (CPD) which was recently confirmed with JWST. The newly derived parameters result in a higher Teff of 2500 K and a more physically expected radius of 1.8 R_J. The mass increases to 27 or 45 M_J, depending on the age used for the system. This result suggests that YSES 1 b resides more in the brown dwarf realm rather than the planetary regime.

Initial Characterization of the Polarimetric Performance of MagAO-X
Miles Lucas (University of Arizona)

We present the design and initial characterization of the new polarimetric mode for the Magellan extreme adaptive optics instrument MagAO-X. The polarimetric mode enables dual-beam polarimetric imaging at r, i, and z filters using a switching HWP for instrumental polarization control. We will present lab characterization and on-sky observations of polarized standard stars to determine the polarimetric accuracy and precision of MagAO-X. We will discuss prospects for optimal polarimetry based on this initial characterization and its applications to other instruments, such as SCExAO and GMagAO-X.

Starlight Suppression with Photonic Integrated Circuits: Laboratory Characterization and Future Applications for Subaru/GLINT and HWO
Mona El Morsy (UTSA)

Directly imaging Earth-like planets around Sun-like stars requires starlight suppression on the order of $\sim 10^{-10}$. Nulling interferometry offers a pathway to achieve this extreme level of suppression at small angular separations challenging for or inaccessible to coronagraphs (∼1–2 lambda/D), suppressing stellar light through destructive interference while transmitting off-axis planet light. Photonic integrated circuits (PICs) have emerged as compact, stable platforms for implementing nulling interferometers. In this talk, I describe the laboratory characterization of one such application of PICs for Glint on Subaru and HWO, tested at UTSA and developed by Macquarie University. Our design focuses on a photonic chip incorporating an integrated thermal phase shifter. In this setup, light from the telescope pupil is split into sub-apertures injected into single-mode waveguides. I describe how this approach differs from that of conventional PICs, where the thermal phase shifter in our setup provides an active tuning to correct for optical path differences and thus sustaining deep null performance.

Toward Broadband High-Contrast Imaging: Coronagraphic Phase Masks and an Auxiliary Optical Module for Wavefront Control
Naoshi Murakami (ABC, NAOJ, SOKENDAI, Hokkaido Univ.)

Advancing broadband high-contrast imaging technologies is essential for a wide range of exoplanetary science, including spectroscopic characterization to investigate planetary atmospheres and surface environments, as well as multi-band photometric observations to enable planetary surface mapping. We are developing coronagraphic optical devices and an auxiliary optical module for wavefront control aimed at broadband high-contrast imaging ultimately toward exploration of habitable exoplanets. First, we are developing focal-plane segmented phase masks (e.g., eight-octant, twelve-sector phase masks, and so on), which are regarded as discretized designs of the vortex phase masks with various orders. We expect that the segmented phase masks are advantageous in terms of their relatively smaller inner working angles with higher core throughput. The masks are composed of three-layer photonic crystal half-waveplates with different optic axes. Several prototype phase masks have been fabricated so far, and their performances have been evaluated by using the self-developed coronagraphic laboratory simulator and spectroscopic ellipsometer. Second, we are also developing the wavefront control technique using a simple auxiliary optical module in front of deformable mirrors (DM) aimed at multi-band simultaneous dark hole digging. The optical module splits a telescope beam into multiple spectral bands and applies different operations to each band so that the DM wavefront control modes do not overlap across the spectral bands. Recently, we constructed the early prototype in the laboratory. In this presentation, we will report on our recent activities related to these technologies.

Overview and status of Keck/HISPEC, the diffraction-limited y-K band spectrograph for exoplanet characterization

Nemanja Jovanovic (Caltech)

The High-Resolution Infrared Spectrograph for Exoplanet Characterization (HISPEC) is a new instrument for the W. M. Keck Observatory that enables R$\sim$100,000 spectroscopy simultaneously across the y, J, H, and K astronomical bands (0.98-2.5μm). It is optimized for exoplanet science cases including precision radial velocity, transit spectroscopy, direct spectroscopy and fiber nulling. It consists of a front-end instrument which steers the adaptive optics corrected beam delivered by Keck to single-mode fibers and stabilizes them during the observation, a fiber delivery subsystem that routes the light around the observatory with the aid of switches, a calibration subsystem with a wide range of light sources, and spectrometers designed to be ultra-stable located in the basement. HISPEC incorporates many cutting-edge technologies to push performance down to 15th mag. Some examples include direct-ruled Echelle and cross-disperser gratings from CANON which are extremely efficient, a 3-port photonic lantern to boost coupling at shorter wavelengths, various phase masks including phase knifes and scalar and vector vortices to enable nulling, mechanical and MEMS switches to enable flexibility in calibration, and laser frequency combs and etalons that span the science bandpass. HISPEC is now in full-scale development with all sub-systems being built and tested in the laboratory. We will provide a technical overview of the design of HISPEC and elucidate the novel technologies incorporated in the design, show progress in laboratory integration and testing, and provide an update on the timeline for instrument deployment and commissioning.

GPI 2.0 End-to-end Simulations

Nicole Wolff (University of California, Santa Cruz)

The Gemini Planet Imager Upgrade (GPI 2.0) is undergoing final testing before it is integrated into the Gemini North Telescope on Mauna Kea. The upgrade includes a pyramid wavefront sensor and advanced apodized-pupil Lyot coronagraph masks designed to block both telescope structures and bad DM actuators. In preparation for instrument commissioning and first light observations, we present results of end-to-end simulations of the GPI 2.0 adaptive optics (AO) system and coronagraph that span stellar magnitude, exposure time, and seeing conditions. The first purpose of these simulations is to prepare for final integration and commissioning. As part of this, we investigate the alignment tolerance of coronagraphic optics under atmospheric conditions realistic to Mauna Kea. The second purpose is to optimize AO control parameters and observing modes. We quantify AO performance as a function of stellar magnitude, seeing, and control gain. The end result of these simulations is an exposure time calculator and sensitivity predictor. Finally, we present simulations of Io, an extended object which will be observed during commissioning to validate AO performance.

MEC Prime: Upgrading MKID Exoplanet Camera for the Next Generation of High Contrast Exoplanet Imaging

Nikki Anita Zivkov (University of California, Santa Barbara)

MEC Prime (MEC') is an upgraded version of the MKID Exoplanet Camera (MEC) that will yield high contrast exoplanet images with higher spectral resolution, more consistent cryostat operation, and streamlined post-processing techniques. Deployed on the Subaru Telescope in 2018, MEC is a visible to near-infrared (800-1400nm) Integral Field Spectrograph (IFS) housed in the body of an adiabatic demagnetization refrigerator (ADR). Its primary technology is a detector array consisting of 20,400 Microwave-Kinetic Inductance Detectors (MKIDs). The MKID array is superconducting, energy resolving, and photon counting on microsecond timescales with no read noise or dark current. During its initial observing period, MEC discovered brown dwarfs and demonstrated stochastic speckle discrimination for precise speckle correction, a relatively new method of removing quasistatic speckles. Since its initial commissioning in 2018, significant improvements have been made in the fabrication of the MKID array, quantum limited amplification to reduce amplification noise, room temperature FPGA readout electronics, and cryostat performance. The new MEC Prime instrument will include all of these upgrades, as well as an additional Chase Cryogenics GL7 Sorption cooler within the frame of the existing ADR to provide additional cooling power to the parametric amplification stage. MEC Prime will be a unique, high contrast imager intended to capture exoplanets within the habitable zone in reflected light. This instrument upgrade is in progress currently and is expected to have its first observations at Subaru in late 2026.

Scalar Vortex Phase Masks for Exoplanet Direct Detection
Niyati Desai (JPL)

The direct imaging of Earth-like exoplanets requires coronagraphs capable of extreme starlight suppression across broad spectral bandwidths. High performing coronagraphic masks are the crucial key to achieving this. Scalar vortex coronagraphs offer a promising solution for HWO due to their polarization insensitivity, but their chromaticity limits starlight suppression. We present our current efforts toward achieving an achromatic scalar vortex phase mask. We explain the theory behind the latest dimpled scalar vortex prototype and show the best broadband contrast results to-date of a scalar vortex coronagraph on JPL's In-Air Coronagraph Testbed. We also explore the application of scalar vortex phase masks to vortex fiber nulling for ground-based instruments like HiSPEC. We show that combining the vortex with a linear phase gradient can compensate for the chromatic displacement of the null and present a laboratory demonstration on the PoRT testbed at Caltech.

High Contrast Imaging with the CACAO real-time software framework
Olivier Guyon (Subaru Telescope & UofArizona)

The Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) system, fed by its upstream 3000-actuator "woofer" (AO3k), serves both as a platform for high contrast imaging (HCI) technology maturation and as a science instrument for imaging, spectroscopy, and polarimetry of exoplanets and disks. SCExAO operates in the visible and near-IR and offers a wide choice of instrument configurations.I will observe Over the last year, AO3k/SCExAO underwent significant upgrades to bring improved capabilities and support new developments, all while easing science operations. The new configuration features a beam switcher so that light can be shared between several instrument modules, including the upcoming NINJA near-IR spectrograph and the SPIDERS HCI pathfinder. The system is evolving toward a tighter integration between multiple WFSs and AO stages of correction, with the first stage (AO3k) providing visible and nearIR WFSing, as well as laser tomography. The system is also increasingly integrating emerging photonic technologies (optical fibers and optical photonic circuits) for improved wavefront sensing, starlight suppression and high accuracy science measurements. These changes are aligned with several overlapping emerging axes of research in HCI systems: (incl. high performance wavefront control, astrophotonics, and PSF calibration) that are driving the design of future systems for large ground and space telescopes.

The PCS instrument at the ELT: definition of science cases and expected science yield
Oscar Carrion-Gonzalez (MPIA)

The Planetary Camera and Spectrograph (PCS) is a planned ELT instrument aimed at detecting and characterizing low-mass, low-temperature exoplanets with high-contrast imaging observations. The PCS R&D roadmap collaboration has now been established, tasked with defining the main science objectives of PCS, developing the instrumental concept and deriving the instrument budgets, and analysing the scientific capabilities of the proposed concept. This will lay the groundwork for the subsequent design and construction phases. Among the work packages within the PCS R&D roadmap, WP1 is in charge of defining the main science cases and the top-level requirements for the instrument. WP7, on the other hand, is devoted to computing yield predictions for the instrument. These computations are a key to understanding the scientific potential of PCS, to robustly defining the instrument specifications and concept, and to ultimately understanding the population of exoplanets that it will be able to detect and characterize. Yield predictions also allow us to carry out trade-offs during the design phase, quantifying how different performance scenarios would impact the final set of detectable targets. In this talk, we will describe the main science cases identified by the PCS R&D WP1, and show preliminary science yield estimates computed by WP7. We will discuss the unique population of exoplanets that PCS will access, as well as the potential synergies with other instruments for a subset of those targets, which will be excellent cases for atmospheric characterization.

Real-Time Vibration Control with Accelerometers for MagAO-X

Parker Thomas Johnson (University of Arizona)

Mechanical vibrations are a significant source of wavefront error (WFE) in ground based adaptive optics (AO) systems. We are currently forced to use stellar photons to correct these vibrations. This reduces the bandwidth available for correcting atmospheric turbulence and makes the correction heavily dependent on guide star brightness. To address this problem, we mounted accelerometers on the back of the secondary mirror of the Clay Magellan telescope, enabling direct measurement of structural vibrations. These accelerometers will be used for real-time vibration control within the Magellan Adaptive Optics eXtreme (MagAO-X) system to improve correction of WFE by constantly sampling at 8kHz, independent of guide star brightness. In the physical system, the analog signals from the sensors are first passed through a signal conditioner, then through a voltage clamping and dividing circuit to ensure safe voltage levels. These signals are digitized using a 10-bit analog-to-digital converter, read by a Raspberry Pi, and transmitted through a direct wired connection to MagAO-X's real-time control computer. The preliminary power spectral density (PSD) results show a correlation between the vibrational signals from the accelerometers and the residual error in our wavefront sensor (WFS). Vibrations are shown to account for ≈35% of the power in both tip and tilt in the WFS measurements. This low-latency pipeline will allow vibration data to be incorporated into the system's control loop with minimal delay, enabling real-time correction of tip, tilt, and focus. This will result in a more stable optical system allowing us to detect fainter companions. This work demonstrates a low-cost solution to mitigate vibrations for current and future ground-based AO systems, including the GMT.

Autodifferentiable PSF modeling for the VLT/ERIS vortex coronagraph

Patricia Van de Walle Suárez (University of Liège)

The Enhanced Resolution Imager and Spectrograph (ERIS) at the VLT is a second-generation mid-infrared instrument, with improved diffraction-limited HCI capabilities. Currently, ERIS stands as the most advanced ground-based instrument for mid-infrared high-contrast imaging, offering among others a vortex coronagraphic mode. Despite the scientific achievements of the vortex coronagraph owing to its small inner working angle and high throughput, its on-sky measured performance remains relatively far from its theoretical limit, due to fast residual jitter and aberrations. Aware of these limitations, and in an effort to optimally exploit the scientific observations, we have recently developed a differentiable optical model of the ERIS vortex coronagraph, where physical parameters are optimized via gradient-based methods to reconstruct the post-coronagraphic point spread function (PSF) with high fidelity. We are now exploring the integration of real-time adaptive optics wavefront telemetry to account for fast temporal wavefront variations and enable robust on-sky applications of our approach. In this contribution, we present our framework and early proof-of-concept results using on-sky ERIS data, illustrating the potential of this method to improve the post-processed contrast. While preliminary, these results highlight the potential of model-driven post-processing for current and future HCI instruments, including ELT/METIS.

Evaluating MICADO's High-Contrast Mode for Direct Imaging of Exoplanets and Disks

Pierre Baudoz (Observatoire de Paris)

MICADO, the first-light near-infrared imager for the European Extremely Large Telescope (ELT), will feature a dedicated high-contrast imaging mode designed specifically for observing and characterizing exoplanets and circumstellar disks. Offering significantly improved sensitivity and angular resolution over current instruments like SPHERE and GPI, MICADO is poised to make major contributions to our understanding of planetary systems. The instrument will include a comprehensive set of coronagraphic tools, comprising three classical Lyot coronagraphs, a vector-apodizing phase plate (vAPP), and two sparse aperture masks. Extensive numerical simulations predict that MICADO will expand the search space for young, massive exoplanets to closer orbital separations (a few AU) around nearby stars and to stars in more distant stellar associations (100–150 pc). This enhanced capability will also support strong synergies with GAIA and radial velocity studies. MICADO's improved resolution and sensitivity will also enable the detection of fainter, more distant debris disks than currently possible with SPHERE, and allow for more detailed imaging of the nearest disk systems. Additionally, the instrument will feature a long-slit spectroscopic mode with high spectral resolution (R = 20,000), enabling in-depth studies of exoplanet atmospheres. This contribution will present the expected performance of MICADO's high-contrast mode, illustrate potential science applications for exoplanet and disk observations, and provide quantitative estimates of its detection capabilities.

Single Conjugate Adaptive Optics performance on METIS/ELT: Simulations, robustness analysis and impacts on high-contrast imaging science cases
Raphaël Pourcelot (MPIA)

METIS, the Mid-infrared ELT Imager and Spectrograph, will be one of the first instruments deployed on ESO's 39-meter Extremely Large Telescope (ELT), currently under construction. Operating in the thermal/mid-infrared range (3–13.3 μm), METIS will deliver diffraction-limited imaging and spectroscopy, including coronagraphic capabilities, with all observing modes relying on its Single Conjugate Adaptive Optics (SCAO) system. Among these, high-contrast imaging imposes the most stringent performance requirements. This work details the implementation of the pyramid wavefront sensor, the real-time controller (RTC), and the wavefront control system. A digital twin of the system has been developed in a simulation environment using the Compass platform. We present key results from robustness analyses, particularly regarding the impact of coronagraphic components in the optical path, along with comprehensive performance predictions, with a focus on the high-contrast imaging science case.

First Light for Near-Infrared Polarimetry on Keck/NIRC2
Rebecca Zhang (UC Santa Barbara)

The Keck/NIRC2 infrared imager is currently being upgraded with a new suite of polarimetric observing modes. The polarimetry upgrade will open up a wide range of new studies, including investigations of exoplanets, the Galactic center, active galactic nuclei and the solar system. This mode will be particularly useful for the high-contrast imaging of circumstellar disks, where polarized differential imaging enables detection of lower surface brightness disks. The new modes enabled by the upgrade span the 1.1 to 4.1 μm range (J through L' bands) and include imaging polarimetry, coronagraphic imaging polarimetry, and spectropolarimetry with both natural and laser guide star adaptive optics. Installation was recently completed with the installation of two half-wave plate modulators (one for J/H/K and one for L') in late Summer 2025. The half-wave plates have been thoroughly characterized in lab, and commissioning observations are scheduled for Semester 25B, with the goal of making these modes available in 2026. This talk will describe the new observing mode's design, capabilities, preliminary science results, and other potential science cases.

Extreme adaptive optics with machine learning: On-sky demonstration with MagAO-X and towards the ELT's
Rico Landman (NOVA)

Direct imaging of rocky exoplanets in the habitable zones of nearby M-dwarfs requires extreme contrasts at small angular separations, pushing extreme adaptive optics (XAO) systems to their limits. Two dominant error terms constrain performance from the ground: photon noise in the wavefront sensor and temporal bandwidth error in the control loop. We present a nonlinear reconstructor for the unmodulated Pyramid Wavefront Sensor (PWFS) based on convolutional neural networks. Our machine-learning (ML) algorithm recovers the dynamic range of the unmodulated PWFS while retaining its higher sensitivity. This allows us to reduce photon noise error and increase loop speeds, enhancing contrast at small angular separations. In this talk, we will discuss the real-time implementation of the algorithm and show on-sky results with MagAO-X, demonstrating stable performance under a variety of conditions. We also present simulations of ML-enhanced PWFS operation on future Extremely Large Telescopes (ELTs), showing potential gains for high-contrast imaging. These results establish ML-enhanced wavefront sensing as a promising path forward for next-generation high-contrast imaging instruments on both current 6–10 m telescopes and the ELTs.

A midplane analysis of HD110058's warped debris disk
Ronald Alexander Lopez (UC Santa Barbara)

We present scattered-light images in the near infrared of the spatially resolved debris disk around HD 110058 in H-band total intensity using observations from Gemini Planet Imager (GPI). With near-infrared scattered-light imaging, we can examine the population of some of the smallest dust grains that populate the disk, and attempt to probe part of the dynamical history of the planetary system by examining its structure. For HD 110058, we discuss the morphological characteristics of its edge-on debris disk and the methods that will be used to study the disk's dynamical history. The presence of an asymmetric warp in the disk at a radius of 0.35 arcseconds (38 AU) is revealed in PSF subtracted total intensity images, sharing some characteristics with the disk around β Pictoris. The warp suggests the existence of large-scale dynamical perturbations due to a possible unseen planet or other dynamical processes such as stellar flybys, or massive collisions.

The Active DAG/PLACID Coronagraph: Discovery Space and Binary Star Observing Mode
Ruben Tandon (University of Bern, Switzerland)

The Programmable Liquid-crystal Active Coronagraphic Imager for the 4-m DAG telescope (PLACID) is the world's first adaptive stellar coronagraph, capable of software-only real-time adjustment to changing observing conditions. The core of PLACID is a liquid crystal spatial light modulator (SLM) panel, acting as a programmable scalar focal-plane phase mask (FPM) coronagraph, covering H- to Ks-bands. The SLM enables to re-program the FPM pattern, free of actuator motion, offering high flexibility. Some advantages of using such an instrument include self-calibration of non-common path aberrations (NCPAs), multiple star coronagraphy, and time-domain coherent differential imaging (CDI). In early 2025, the PLACID instrument was installed on the diffraction-limited Nasmyth platform of the 4-m DAG (Doğu Anadolu Gözlemevi) telescope as part of the Turkish National Observatories (TNO) in Erzurum. PLACID first light is expected in the first half of 2026. In this work, we detail the PLACID discovery space based on a dedicated exposure time calculator, lab measurements and simulations, allowing to plan future high-contrast observations. The calculations include AO performance, contrast, limiting NGS magnitudes, and inner working angle. When on-sky, PLACID will target known directly imaged exoplanets, young binaries, brown dwarfs, and circumstellar disks. Additionally, a key asset of PLACID is to enable high-contrast imaging surveys of multiple star systems in combination with angular differential imaging (ADI). To this end, the PLACID data reduction pipeline (based on the PynPoint python package) and the instrument graphics user interface (GUI), that have been implemented, also include a binary star mode. In the latter configuration, the FPM on the secondary star automatically follows the field rotation during an ADI sequence. The PLACID data reduction process, its binary star observing mode and first on-sky results, if available at the time, are hereby presented.

Coronagraph Design Survey and Performance Analysis for the Habitable Worlds Observatory
Ruslan Belikov (NASA Ames Research Center)

NASA has embarked on an ambitious program to develop the Habitable Worlds Observatory (HWO) flagship to perform transformational astrophysics, as well as directly image ~ 25 potentially Earth-like planets and spectroscopically characterize them for signs of life. The coronagraph instrument is a critical part of HWO, tightly coupled to exoplanet science yield, as well as to some of the most challenging requirements, such as contrast and telescope stability. Fortunately, coronagraph trade space is very rich, with many "levers" to improve performance and relax requirements on HWO, but this requires broader trades and deeper optimizations than have ever been performed in the past.

To facilitate such trades, a Coronagraph Design Survey (CDS) was recently completed, summarizing many of the currently viable coronagraph options and quantifying many of the levers. In this work, we summarize the results of the CDS as well as present an update with new designs for HWO "Exploratory Analytical Cases" (EACs). In particular, we will present: (1) a database of different coronagraph designs sourced from the world-wide coronagraph community that are potentially compatible with HWO; (2) analysis of engineering performance for these designs, such as throughput, inner working angle, sensitivity to aberrations, contrast, and how these trade against each other; (3) preliminary analysis of expected exoplanet science yields for these designs; (4) analysis of how performance depends on select high-priority parameters, such as segment gap size, off-axis vs. on-axis aperture, obstruction size and strut size; (5) an assessment of the current laboratory demonstrations and design maturity.

GPI 2.0: Adaptive Optics Upgrade
Saavidra Perera (UCSD)

The Gemini Planet Imager (GPI) is a high-contrast imaging instrument designed to directly detect and characterise young, Jupiter-mass exoplanets. After six years of operation at Gemini South in Chile, the instrument is being upgraded and moved to Gemini North in Hawaii as GPI 2.0. Several improvements have been made to the adaptive optics system as part of this upgrade. This includes replacing the current Shack-Hartmann wavefront sensor (WFS) with a pyramid wavefront sensor (PWFS) and custom EMCCD, and employing the Herzberg Extensible Adaptive Real-Time Toolkit (HEART). These changes will increase GPI's sky coverage by accessing fainter targets, improving corrections on fainter stars, and enabling faster and ultra-low-latency operations on brighter targets. The PWFS subsystem was independently built and tested to verify its performance before being integrated into the GPI 2.0 instrument. Here, we will present performance and calibration test results, including linearity, closed-loop wavefront quality, and HEART functionalities and performance.

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2 Fast 2 Furious: Focal Plane Wavefront Sensing Through A Coronagraph
Sam Walker (UHIfA)

We present 2 Fast 2 Furious, an algorithm for focal plane wavefront control with a coronagraph in the optical path. Our algorithm builds on the existing Fast and Furious algorithm, which has been proven to work swiftly in the loop on the bench and on sky to suppress wavefront aberrations and improve PSF quality. We adapt the formalism of Fast and Furious to incorporate a coronagraph focal plane mask and Lyot stop. We present bench data from successful testing with the Palila camera on SCExAO. This is the first sequential phase diversity focal plane wavefront control algorithm shown to work with a focal plane coronagraph, facilitating higher-contrast observations at closer angular separations than previously possible.

Calibration of MEMS DM actuator gains using a Zernike Wavefront Sensor on the HiCAT Testbed
Sarah Steiger (Space Telescope Science Institute)

Deformable mirrors (DMs) are a key component of coronagraph instruments performing adaptive optics on the ground, and for future space observatories such as HWO and Roman CGI. Here, they will be used as part of the wavefront sensing and control system to "dig a dark zone" – remove residual stellar light to create a high-contrast region in the focal plane where faint companions can be detected and characterized. To reach the contrasts needed to directly image cool or reflected light planets (¡1e-8) accurate calibration of the DM actuator gain is essential as picometer differences between the expected and realized DM surface can significantly degrade dark zone (DZ) digging efficiency. This increases the overheads needed to achieve a DZ and critically places more stringent requirements on observatory stability as the level of tolerable drift decreases with the required iterations to achieve the desired contrast. Furthermore, DM gain varies with actuator stroke, necessitating rapid, in situ gain map recalculations to maintain DZ digging efficiency over time. Zernike wavefront sensors (ZWFS) are well-suited for this task as they provide picometer-level sensitivity and will likely already be included on board as part of a low order wavefront sensor for HWO. Using the ZWFS for DM calibrations however will have significant operational implications for the observing strategy of HWO and so must be investigated early. Here we present results from the HiCAT testbed at STScI where we calibrated gain maps for our Boston Micromachines 952-actuator micro electromechanical (MEMS) DMs using both a Fizeau interferometer and a ZWFS to compare performance. With the ZWFS we demonstrate sub-nm sensitivities and compute a gain map using both local linear fits around a given DM solution, as well as more complex quadratic solutions which are more computationally intensive, but accurate over most of the dynamic range of each actuator.

Characterizing Planets with ELT/METIS Near the Circumstellar Ice Line
Sasha Hinkley (University of Exeter)

The recent direct detections of a small number of Jovian mass exoplanets orbiting nearby young stars at 2-4 AU (e.g. HD206893c, AF Lep b, and beta Pic c) using optical interferometry with instruments like VLT/GRAVITY are serving as a preview for future direct imaging discoveries for ELT instruments such as METIS and MICADO that will have vastly superior inner working angles and sensitivity compared to any previous direct imaging platforms. In my presentation I will showcase the predicted direct imaging sensitivity of METIS to such planets at orbital separations of 2-4 AU near circumstellar ice lines and coincident with the peak of the orbital distribution as defined by previous radial velocity surveys. Specifically, I will discuss recent simulations of the METIS coronagraphic sensitivity to young planets orbiting stars in nearby young moving groups as well as more distant, star forming regions like the Scorpius-Centaurus OB Association using both coronagraphy and sparse aperture masking. For very young systems like PDS 70, the sparse aperture masks that are currently being commissioned for METIS will deliver sensitivity to truly planetary mass companions at separations of only 2-4 AU. Depending on the initial performance of the METIS AO system, these sparse aperture masks may indeed deliver the very first high contrast science with METIS on the ELT. The 3-5 micron wavelength coverage of METIS, near the peak of the thermal emission of these planets, combined with dynamical information from Gaia, will be a breakthrough for calibrating theoretical evolutionary and atmospheric models of these objects and assessing the early thermal histories of planets shortly after formation.

Development Progress of wide-spectral-band combined nuller systems using the one-dimensional diffraction-limited coronagraph
Satoshi Itoh (Nagoya University)

Spectral observations of the directly detected planets require wide wavelength bands of the coronagraphic instruments. In this presentation, we report on the development progress of wide-spectral-band serially conjoined nuller systems using the one-dimensional diffraction-limited coronagraph (1DDLC). The 1DDLC offers promising features, such as a binary null ability like the band-limited mask coronagraph and small inner working angles like the phase-induced amplitude apodization complex-mask coronagraph (PIAA-CMC), but its starlight-suppression performance at the diffraction-limited (about 1lambda/D) separation angles is affected by spectral bandwidth. This is because speckle nulling sufficiently works for the wavelength-deviation leak only at the non-diffraction-limited separation angles. Nevertheless, in the 1DDLC, wavelengths deviated from the design wavelength introduce leaks with a flat wavefront on the Lyot-stop plane. This leak can be removed by the successive nuller. Hence, conjoined nuller systems using the 1DDLC can achieve wide spectral bands even at diffraction-limited (about 1lambda/D) separation angles. So far, a monochromatic experiment without active wavefront controls demonstrated the starlight-suppression ability of the 1DDLC to at worst a 10^{-5} level. With the same experimental setup, we have also confirmed the PSF profile of the leak from the 1DDLC due to the wavefront deviation from the design-center wavelength same as the profile of the on-axis point source. In this setup, we implemented the focal-plane mask using a method similar to but different from the vector vortex mask coronagraph. The possible second-stage nuller includes photonic-integrated-circuit (PIC) nullers and fiber nullers. An experiment adopting a fiber nuller as the second stage has shown that the combination of the two nullers actually broadens the spectral bandwidth. For future demonstration of the combination of the 1DDLC and the PIC, designing a connection part between nullers is ongoing. We plan to conduct the demonstrations in cooperation with wavefront correction technologies in the future.

Closing the technology gap for the Extremely Large Telescope's Planetary Camera and

Spectrograph (ELT-PCS): development of the coronagraph and focal plane wavefront control strategies
Sebastiaan Haffert (Leiden Observatory)

The advent of the 39-meter European Extremely Large Telescope (ELT) will mark a transformative step for exoplanet science, offering unprecedented sensitivity and spatial resolution for direct imaging. At the forefront of this effort is the Planetary Camera and Spectrograph (PCS), the ELT's dedicated instrument for exoplanet characterization, with a central goal of discovering and studying rocky exoplanets. To prepare for these ambitious objectives, the PCS R&D consortium, launched in January 2025 under ESO's leadership, was established to advance the conceptual design and bridge critical technology gaps. In this presentation, I will report on the progress of the coronagraph and focal-plane wavefront control work package. Our efforts focus on the development of coronagraphs tailored for PCS and on strategies for integrating wavefront control into their operation. A key component of this work is the PCS Coronagraph Evaluation Pipeline (PCS-CEP), designed to provide a uniform framework for assessing coronagraph performance, an approach inspired by the Habitable Worlds Observatory coronagraph design survey. PCS-CEP enables a fair comparison of diverse concepts, ensuring a level playing field for innovation. I will highlight the interplay between coronagraph development, wavefront control, and performance evaluation, and discuss opportunities for the wider community to participate in the development of PCS's coronagraph science instrument.

Detectability of O2 in Simulated Low-Resolution Reflected Spectra of Earth-like Planets Observed with HWO
Simon Petrus (NASA Goddard Space Flight Center)

Spectral resolution is a critical parameter for future flagship missions aiming to detect and characterize Earth-like exoplanets. Previous studies suggest that visible-wavelength spectrographs require R$\sim$150 to detect the 760 nm O2 absorption feature. We investigated this requirement in the context of a lenslet-based integral field spectrograph (IFS) design for the Habitable Worlds Observatory (HWO). Our end-to-end simulations combine numerical models of a segmented space telescope, coronagraph, and IFS to generate high-fidelity observations of a "twin Earth" exoplanet. We explored a range of spectral resolutions (R=100-500), and SNRs (5-20) simulating 100 noise realizations for each combination, including/excluding speckles. For each simulated observation, we infer planetary properties with the Bayesian retrieval code ForMoSA, using forward models from the Barbie grid of Earth-like spectra produced with the Planetary Spectrum Generator. Our results show that observations with SNR$\sim$15 can yield weak to moderate detections of O2 for R>100. Using Bayes factors, we further highlight the importance of including O2 in the retrieval models. Finally, we assess the impact of correlated noise on these results.

Photonic-Enabled ExoPlanet Spectroscopic Sensor (PEEPSS) for Focal Plane Wavefront Sensing and Imaging Spectroscopy on HWO
Stephen Eikenberry (CREOL - University of Central Florida)

We present an overview of the Photonic-Enabled ExoPlanet Spectroscopic Sensor (PEEPSS) to simultaneously provide post-coronagraph focal plane wavefront sensing and imaging spectroscopy for exoplanet observations. PEEPSS will significantly enhance the performance of high-contrast imaging and spectroscopy on large space telescopes such as the proposed Habitable Worlds Observatory (HWO) mission. The scientific goal of detecting and characterizing habitable extrasolar planets around other stars requires extremely high contrast levels of $\sim 10^{10}$ demands exquisite knowledge and control of the system's optical wavefront, making wavefront sensors (WFS) one of the three key technology needs for these missions. While existing technologies are already at high Technology Readiness Levels, with upcoming deployment on the Roman Space Telescope, HWO lacks the ability to sense the post-coronagraph wavefront in the proposed mission, creating a high risk that these will be "necessary but not sufficient" for the task. PEEPSS employs photonic lanterns to efficiently couple light from the inner dark hole in the coronagraph focal plane into single-mode optical fibers that feed a separate science-grade spectrograph, providing post-coronagraph focal plane WFS and imaging spectroscopy of exoplanet. The focal plane sensing eliminates non-common-path aberrations that could otherwise prevent HWO from achieving the ultimate scientific performance goals. At the same time, it also provides science-quality spectra of the exoplanet candidates in the dark hole field and even of the host star via the residual starlight. While other focal plane wavefront sensor technologies exist, PEEPSS is uniquely compatible with the proposed designs for HWO coronagraphy due to its compact package and sensitivity to the amplitude and phase of the focal plane light distribution across a large wavelength band, and simultaneous enabling of scientific spectroscopy. Furthermore, PEEPSS potentially improves the yield of NIR-detected exoplanets via a smaller inner working angle.

On-sky demonstration of the high transmission, high resolution VIPA spectrograph for close companions
Steven Martos (IPAG)

The PAPYRUS AO system at the 1.52m telescope of the Haute-Provence Observatory (OHP) has been used in 2025 to feed the NIR high-resolution VIPA spectrometer. The VIPA spectrometer has been demonstrated to achieve a 38% throughput in a 225nm spectral range centered at 1.65μm. A dedicated fiber injection unit has been designed and installed to send light into the two monomode fibers connected to VIPA. The calibration of the spectrometer and the data reduction pipeline have been improved over a few observations runs, which also served to measure the relative RV precision (10m/s). Spectra template matching has been demonstrated looking at feature rich stars. The tracking accuracy of off-axis targets at 1-2" has been measured to be 0.1λ/D. Thanks to this set-up, it was possible to observe stars of various spectral types and magnitudes, or close companions. This allows to validate our ETC predictions and assess the operability and the interest of this concept for its use on future high-contrast instruments for high resolution exoplanet characterization.

Dark zone maintenance for the Habitable Worlds Observatory
Susan F. Redmond (JPL, Caltech)

In order to directly image and characterize Earth-like exoplanets, the Habitable Worlds Observatory will be required to control or correct for waverfront errors on the order of picometers. Due to the limited flux of these exoplanets, this stability will need to be maintained for tens of hours. While major strides are being made in thermal and rigid body control of the primary mirror segments, some form of real-time wavefront sensing and control during science observations will be required in order to meet the HWO science goals. Ideally, the observing strategy, dark zone maintenance (DZM) scheme, and post-processing algorithms are optimized together to maximize the potential science yield. Here we discuss a dark zone maintenance algorithm that uses an extended Kalman filter to estimate the coherent electric field separate from the incoherent intensity in the science images using a single image per iteration. The correction applied to the deformable mirrors is calculated using electric field conjugation. We demonstrate the DZM performance with the exploratory analytical concept one (EAC1) in the presence of realistic drifts. The wavefront sensing probe applied to the deformable mirrors each iteration is strategically chosen to facilitate post-processing and post-processed results using angular differential imaging and speckle smoothing are provided.

Direct Imaging of Protoplanet Candidates in Protoplanetary Disks Using VLT/ERIS NIX L-band Observation
Swastik Chowbay (University of Milan)

We present our study using the VLT/ERIS NIX imager observations at 3.8 μm to directly detect protoplanet candidates responsible for the observed kinematic signatures in protoplanetary disks. By taking advantage of the long-wavelength sensitivity of the L-band, we aim to reduce the impact of circumstellar and circumplanetary dust extinction, significantly improving our ability to resolve thermal emissions from embedded protoplanets. Our targets, identified through ALMA observations of prominent spiral structures and kinematic deviations, are ideal candidates for direct imaging. This work aims to confirm the planetary nature of these features and provides initial constraints on the luminosities of the detected planets. These observations represent a crucial step in integrating kinematic and photometric techniques to calibrate the mass-luminosity relationship of young protoplanets and enhance our understanding of planet formation processes. Our findings highlight the potential of combining ALMA and NIX data to advance the study of planetary genesis in diverse disk environments.

Constraints on the Orbit of the Young Substellar Companion GQ Lup B from High-Resolution Spectroscopy and VLTI/GRAVITY Astrometry

Vidya Venkatesan (UC Irvine)

Understanding the orbits of giant planets is critical for testing planet formation models, particularly at wide separations (>10 au) where traditional core accretion becomes inefficient. However, constraining orbits at these separations has historically been challenging due to sparse orbital coverage and related degeneracies in the orbital parameters. In this work, we use existing high-resolution ($R \sim$ 100,000) spectroscopic measurements from CRIRES+, astrometric data from SPHERE, NACO, and ALMA, and combine it with new high-precision GRAVITY astrometry data to refine the orbit of GQ Lup B, a ∼30 MJ companion at ∼100 au, in a system that also hosts a circumstellar disk and a wide companion, GQ Lup C. Including radial-velocity (RV) data significantly improves orbital constraints by breaking the degeneracy between inclination and eccentricity that plagues astrometry-only fits for long-period companions. Our work is one of the first to combine high-precision astrometry with the companion's relative radial velocity measurements to achieve significantly improved orbital constraint. The eccentricity is refined from e = 0.47 (+0.14,-0.16) (GRAVITY only) to e = 0.35 (+0.10,-0.09) when RVs and GRAVITY data are combined. We also compute the mutual inclinations between the orbit of GQ Lup B, the circumstellar disk, the stellar spin axis, and the disk of GQ Lup C. The orbit is misaligned by $\Delta i = 63$ (+6, -14)° relative to the circumstellar disk and by $\Delta i = 52$ (+19, -24)° with the host star's spin axis, but appears more consistent ($\Delta i = 34$ (+6 ,-13°)) with the inclination of the disk of the wide tertiary companion GQ Lup C. These results support a formation scenario for GQ Lup B consistent with cloud fragmentation. They highlight the power of combining companion RV constraints with interferometric astrometry to probe the dynamics and formation of wide-orbit substellar companion.

Commissioning a new quad-AGPM coronagraph for mid-IR exoplanet imaging with LBTI

Vivek Vijayakumar (University of Arizona)

High contrast imaging and spectroscopy at mid-infrared wavelengths is important for characterizing thermal emission from exoplanets and is highly complementary to observations of planets in reflected light and other detection methods. For earth-like exoplanets with T∼300K, imaging in the mid-IR also provides more favorable contrast ratios. The first quadruple annular groove phase mask (Q-AGPM) coronagraph is being commissioned for this purpose, optimized for 10 micron wavelengths and is well suited for direct-imaging rocky planets. The Q-AGPM will enable continuous coronographic observations and background measurements, which combined with other improvements will allow the Large Binocular Telescope Interferometer (LBTI) to achieve sensitivities at least 2.5x better than VLT/NEAR and the LBT's prior NOMIC detector in the contrast-limited regime. We present some of the first test results from this coronagraph and from the development of the reduction pipeline.

SPIDERS First Light: a Coherent Path to High Contrast

William Thompson (Herzberg Astronomy and Astrophysics)

We present the first on-sky results from the SPIDERS pathfinder, the first direct imaging instrument designed from the ground up for focal plane wavefront sensing and coherent differential imaging (CDI) with a Self-Coherent Camera (SCC). The SPIDERS' 2nd stage AO system, working downstream of Subaru's AO3K, measures the full complex electric field of speckles at up to 200Hz without requiring any modulation. This allows the instrument to correct for residual speckles in real time and record fringes that can be used to post-process any residual static speckles with CDI, besides or in-addition to ADI or SDI. We will show initial results from on-sky testing and preliminary estimates of contrast improvements. These tests are highly relevant to future studies of exoplanets and disks from the ground, and show what will be possible with the upcoming GPI2.0/CAL2 and show promising directions for possible HWO instrumentation.

Focal plane wavefront sensing and control with mode-sorting coronagraphs

Yinzi Xin (Caltech)

Mode-sorting coronagraphs demultiplex the electric field of the incoming light into different channels, separating out the light of the star from that of potential planets. Mode-sorting can enable the implementation of optimal coronagraphs and aid in the detection and spectroscopy of exoplanets, especially at very close-in separations. Focal-plane wavefront control methods developed for conventional image-plane coronagraphs can also be used to deepen the nulls of mode-sorters, but with the unique property that both phase and amplitude aberrations in the pupil plane can be compensated for with only one deformable mirror. However, while these control solutions are physically possible, they are difficult to identify with traditional pairwise probing techniques. We present simulations that explore focal-plane wavefront control with different mode-sorting devices (e.g. photonic lanterns and multiplane light converters), analyze the impact of probes and regularization parameters on the obtained solutions, and discuss potential strategies for finding more optimal nulls.

A configurable mode-based imager using an active photonic integrated circuit: concept and initial laboratory results
Yoo Jung Kim (University of California, Los Angeles)

Although diffraction typically limits the resolvable angular scale, spatial-mode-based measurements – which measure the image in a modal basis rather than in pixels – enable efficient information recovery below the diffraction limit. This efficiency for centroid measurements was recently demonstrated on-sky using a standard 19-port photonic lantern (PL). While successful, a standard PL, which sorts modes on a fixed random basis, is sub-optimal for sub-diffraction information recovery, as realizing the full potential of this technique requires specifically tuned measurement bases. Even a mode-selective PL (MSPL), which maps each LP mode to each output, suffers from imperfect modal purity, limiting information recovery. Here, I present a novel method to optimize spatial-mode-based measurements for specific science cases by feeding PL outputs into an active photonic integrated circuit (PIC). Within the PIC, thermo-optic phase shifters introduce controlled interference between PL outputs, dynamically tuning the PL's mode-sorting properties. This enables purification of measurement modes, simultaneous nulling and wavefront sensing, and optimization of modes for a known companion's separation and contrast. I also present initial results from ongoing laboratory experiments using a 6-port MSPL feeding an active PIC, highlighting lessons learned for developing a fully configurable mode-based imager.

A VLT/MUSE Survey for Accreting Planets in 75 Protoplanetary Disks
Zhuhai Li (Department of Astronomy, School of Physics, Peking University, Beijing 100871, China)

Using the Multi Unit Spectroscopic Explorer (MUSE) instrument on the VLT, Haffert et al. detected accretion signals in Hα emission from two protoplanets in the PDS 70 protoplanetary disk. Those planets are still forming in disks, and they hold the key to our understanding of planet formation. Inspired by this, a total of 21 MUSE programs to search for accreting protoplanets have been carried out in the past 7 years, targeting 75 protoplanetary disk systems. We process this large sample to search for additional protoplanet candidates in disks. Specifically, more than 30 objects in this sample (e.g., HD 163296, HD 169142, IM Lup, GW Lup, J1604, and TW Hya) have been proposed to host giant planets at specific locations, based on modeling disk structures in NIR imaging and mm observations, including gas kinematics. We search for Hα counterparts at the corresponding planet locations, and by doing so, provide updates on the status of these candidates. In addition, using the HRSDI technique and fake-planet injection and recovery, we estimate the flux detection limit (contrast curves) for each target, and compare these limits to the fluxes of PDS 70 b and c, to assess whether PDS 70 b- and c-like planets are common. Our research can help other HCI instruments that traces Hα signal like MagAO-X to decide which protoplanetary disks merit follow-up observations.

Constraining the Evolution of Substellar Companions with Bayesian Ages: A New Detection from SCExAO/OASIS Survey
Ziying Gu (The University of Tokyo)

The SCExAO team at the Subaru Telescope has launched an intensive survey, OASIS, for substellar companions around accelerating stars. Dynamical masses derived from orbital fitting allow us to compare evolutionary models of age–mass–luminosity relations with observational results. For example, hot (Baraffe et al. 2003) vs. cold start (Marley et al. 2007) are competing hypotheses of initial entropy. Differences between two models are most prominent at young ages ($< \sim$200 Myr), making high-contrast imaging particularly suitable for characterizing such young and hot substellar companions. However, age estimates from the color–magnitude diagram (CMD) suffer from large uncertainties and may even be misleading when metallicity effects are underestimated. Our survey targets are mainly early-type stars (B, A, and early-F), which typically rotate rapidly and exhibit temperature variations across their surfaces, making apparent magnitudes inclination-dependent. We developed software that applies Bayesian analysis to jointly sample six parameters: mass, age, metallicity, rotation, inclination, and parallax. Our method better accounts for parameters affecting age-dating, providing more reliable age estimates than simple CMD-based results. We validated our software with well-known clusters: Hyades (600–800 Myr), Praesepe (600–800 Myr), and Pleiades ($\sim$100 Myr), finding good agreement with previous studies (e.g., Brandt & Huang 2015a,b,c). We further conclude well-constrained extinction and metallicity are essential for reliable ages with small uncertainties. In addition, we will present a newly detected brown dwarf candidate from our survey with a mass of 51 (+12, –16) M_Jup, a semi-major axis of 54.4 (+11, –8.3) AU, and an eccentricity of 0.36 (+0.13, –0.17). Its spectral type is M4–M5, with a Bayesian age of 484 (+248, –235) Myr. The main limitation in age estimation is lacking a tight metallicity prior. With a newly finished follow-up observation, updated orbit parameters will be presented. Detailed studies of its atmosphere and evolutionary pathway are ongoing.
