NASA Hubble Fellowship Program

NHFP

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Student Organization Center at Hilles
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NASA NExScI CXC STScI

Scientific Organizing Committee

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Dawn Gelino, NASA Exoplanet Science Institute
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Abstracts

Danica Adams
Harvard University

Crustal Hydration Primed Early Mars with Warm and Habitable Conditions

Extensive geological and mineralogical evidence suggests that ancient Mars once had large volumes of surface liquid water, but the mass and composition of the ancient atmosphere that sustained the warm climate is unknown. A CO_2 atmosphere thicker than the present day, with a few percent of H_2 or CH_4, was previously posited as a solution. Recent measurements of atmospheric escape and the interpretation of the observed enrichment of heavy isotopes indicate that the transition from the ancient atmosphere to the modern one is driven by not only loss to space, but also formation of carbonates and crustal hydration. This study proposes crustal hydration as a long-lasting source of H_2 in the early atmosphere during warm climates. In this work, we couple KINETCS (the Caltech/JPL 1D photochemical model) with REDFOX (a correlated-k radiative-convective 1D climate module). This study posits that crustal hydration would have released significant fluxes of H_2 into the atmosphere as a result of aqueously incorporating OH to oxidize surface reduced iron and to form hydrated minerals. These H_2 fluxes, built up in the atmosphere over 105-107 years, could have facilitated a warm, wet climate through collision-induced absorption with CO_2 and N_2. We find that this would only occur during a few major events lasting ~million years, while shorter events could not have caused widespread warming of the climate. This study finds that as CO_2 was lost and the atmosphere cooled, the atmosphere may have transitioned to a CO-dominated state during the Hesperian era, leading to a colder, drier climate. Sharp climate and redox state changes may have been triggered by geological or obliquity changes.

Riccardo Arcodia
MIT

X-ray bursts from galactic nuclei

A new cosmic phenomenon was recently discovered and named quasi-periodic eruptions (QPEs). QPEs are X-ray bursts that last minutes to hours and repeat every several hours to a day, originating from galactic nuclei. Only a handful of such sources is known, and their nature is still debated. One of the leading interpretations is that a compact accretion flow around the massive black holes in these galactic nuclei is perturbed by an orbiter with much smaller mass. Some of these systems, referred to as extreme mass ratio inspirals, will be detectable by LISA, making QPEs their first electromagnetic counterpart candidate. I will present the basic properties of QPEs and discuss their role in black hole growth and galaxy co-evolution.

Elias Aydi
Michigan State University

Exploring the formation and characteristics of shocks in novae

Novae, a well-studied type of transient thermonuclear (TN) eruptions taking place in interacting binary stars, have been recently established as a new class of particle accelerators in our Galaxy. This new insight into novae was brought by NASA's Fermi-LAT, which has been detecting GeV gamma-ray emission from several novae in the past decade. A shock-ing discovery, highlighting the presence of energetic shocks in these events. Recent studies proved that these shocks, which are responsible for the GeV gamma-ray emission, could also be powering a substantial fraction of the nova bolometric luminosity, rivaling the emission from the TN reactions. In this talk I will be discussing our recent efforts into exploring the formation and characteristics of these gamma-ray emitting shocks in novae.

Sylvia Biscoveanu
Northwestern University

The gravitational-wave population of neutron star-black hole mergers

Neutron star-black hole (NSBH) mergers detected in gravitational waves have the potential to shed light on supernova physics, the dense matter equation of state, and the astrophysical processes that power their potential electromagnetic counterparts. In this talk, I will present results using the population of four candidate NSBH events detected in gravitational waves so far with a false alarm rate $\leq$ 1 yr−1 to constrain the mass and spin distributions and multimessenger prospects of these systems. I will show that NSBH mergers are unlikely multimessenger sources and describe a method to constrain the neutron star equation of state using electromagnetic counterpart non detections.

Carlos Blanco
Princeton University

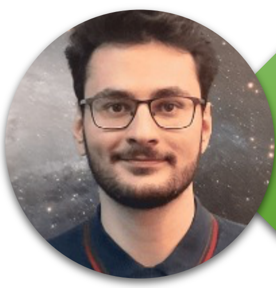
Developments in sub-GeV dark matter detection

Molecular and nano-scale systems are particularly well-suited to look for sub-GeV DM since their eV-scale electronic transitions may be excited through light dark matter interactions. Here, I will discuss the importance of molecular and mesoscopic systems as new directions in the direct detection of dark matter, focusing on the use of quantum dots (QDs) and organic crystals as detector targets. I will show that QDs present a particularly interesting target with inherently low-background signals and low-cost scalability. I will present the molecular Migdal effect as a new directional method to detect DM nuclear recoils using molecular systems. Finally, I will discuss the applications of these formalisms for indirect detection.

Iryna Butsky
Stanford University

What in the Galaxy is Scattering Cosmic Rays?

Cosmic rays affect galaxy evolution on all scales, from ionizing protoplanetary disks and molecular clouds to driving galactic outflows that alter the gas phase hundreds of kiloparsecs from the galactic disk. All models of cosmic-ray physics on “macro” scales (> pc) are sensitive to the assumed models of cosmic-ray scattering on “micro” scales (~ au), which are observationally and theoretically unconstrained. In light of the many challenges facing existing models of cosmic-ray transport, I will present a novel category of “patchy” cosmic-ray scattering that is qualitatively different from the traditional “continuous” scattering models and discuss future observational constraints that could test these models.



Andrei Cuceu
The Ohio State University

Measuring the cosmic expansion rate at high redshift with Lyman-α forests

The Lyman-alpha (Lya) forest is currently one of the most powerful probes of large-scale structure at high redshift ($2 < z < 4$). This is made possible by large spectroscopic surveys that measure hundreds of thousands of quasar spectra, such as the Baryon Oscillation Spectroscopic Survey (BOSS). Over the last decade, 3D correlations of BOSS Lya forests have been successfully used to measure the high redshift expansion rate, and place tight constraints on the nature of dark energy. In this talk, I will present the next stage in the use of Lya forests as a 3D tracer of large scale structure, which includes extracting previously untapped cosmological information, and new data currently coming in from the Dark Energy Spectroscopic Instrument (DESI).

Emily Cunningham
Columbia

Chemical Cartography of the Sagittarius Stream with Gaia

The stellar stream connected to the Sagittarius (Sgr) dwarf galaxy is the most massive tidal stream that has been mapped in the Galaxy, and is the dominant contributor to the outer stellar halo of the Milky Way. I will present metallicity maps of the Sgr stream, using red giant branch stars with inferred metallicities from Gaia. This sample is larger than previous samples of Sgr stream members with chemical abundances by an order of magnitude. Our results provide novel observational constraints for the internal structure of the dwarf galaxy progenitor of the Sgr stream. Leveraging new large datasets in conjunction with tailored simulations, we can connect the present day properties of disrupted dwarfs in the Milky Way to their initial conditions.

Tim Cunningham
Harvard University

White dwarfs as probes of convective overshoot and evolved exoplanetary systems

Using the 3D radiation-hydrodynamics code, CO5BOLD, I study the surface convection zones of white dwarfs. I will present the first 3D simulations of degenerate stars with passive scalar particles that provide a statistical characterisation of the mixing in the overshoot layers below the convective zone. The results of these simulations suggest that enhanced mixing due to convective overshoot decays over at least 2.5 pressure scale heights beneath the convection zone, leading to much larger mixed masses. I will discuss the implications of this result for the inferred accretion rates, masses and compositions of evolved planetary systems, and recent X-ray observations with Chandra which provide a test of these models and confirm metal-polluted white dwarfs as a new class of X-ray source.

Kristen Dage
Wayne State University

Hunting Intermediate Mass Black Holes in Young Star Clusters

Intermediate mass black holes are thought to be one of the primary explanations for how supermassive black holes grow and evolve. Although there is very little observational evidence for intermediate mass black holes, many theoretical simulations suggest that they may be present in young star clusters. However, this has never yet been backed up by observational studies. We are currently undertaking a census of the X-ray binary population of star clusters in 50 galaxies within 10 Mpc to identify and characterize potential intermediate mass black holes in star clusters, and to follow them up with multiwavelength studies to rule them in as intermediate mass black hole candidates, or definitively rule them out. I will discuss our current work on this study and planned future follow-up.

Fei Dai
Caltech

Taking the dynamical temperature of young planetary systems with KPF

Planetary migration and dynamical evolution in our own Solar System, as outlined in the Nice and Grand Tack Models have far-reaching implications for the orbital architecture we see today. How about for exoplanetary systems? The Keck Planet Finder (KPF) is poised to significantly advance our understanding of the formation and dynamical evolution of sub-Neptune planets. We present the stellar obliquity measurement of a young planetary system with two planets close to mean-motion resonance. KPF successfully detected one of the most challenging Rossiter-McLaughlin signals (~2m/s) and the Doppler Shadow (~300ppm). The planet is well-aligned which indicates a quiet dynamical evolution that preserved the resonance and coplanar configuration.

Kishalay De
MIT

The transient mid-infrared sky seen with WISE

The growth of mass in stars and supermassive black holes (SMBHs) underpins every area of astrophysics. It is now becoming increasingly clear that short-lived transient outbursts lasting years to decades possibly dominate the growth processes. Yet, observational studies remain severely limited either due to their intrinsically red emission, or absorption due to intervening dust and gas. In this talk, I will present a new window into these unsolved questions with the NEOWISE mid-infrared survey, revealing i) a complete census of proto-stellar growth through transient outbursts, ii) a new class of dust obscured stellar mergers in lower mass stars, iii) missed tidal disruption events by SMBHs in nearby galaxies and iv) variable accretion in high redshift quasars hidden in the optical bands.

Tarraneh Eftekhari
Northwestern

Unveiling the Transient Sky at Radio and Millimeter Wavelengths

The last decade of investigations of astrophysical transients has led to the discovery of new and all-together unexpected classes of radio and millimeter transients, opening a new window into the dynamic and violent universe. In this talk, I will present our work probing new regions of the transient radio and millimeter phase space, including results from the largest systematic search for late-time radio emission from a volume-limited sample of hydrogen-rich core-collapse supernovae, predictions for millimeter transient detection rates with next generation CMB surveys, and efforts to uncover the as of yet elusive origin of fast radio bursts. I will also discuss prospects for uncovering an entirely new population of radio sources on the sky.

Adina Feinstein
University of Colorado Boulder

Flare Statistics for Stars Younger than 200 Myr observed with TESS

All-sky photometric exoplanet missions have revitalized stellar astrophysics. By obtaining high-precision high-cadence observations of an unprecedented number of stars, TESS has unlocked the potential to understand stellar magnetic activity. Using observable proxies, such as stellar flares, we can begin to understand the evolution of such mechanisms. Previous missions, such as K2, allowed for detailed flare studies in older open clusters. Here, I will discuss preliminary results of identifying and characterizing flares originating from 3200 stars that are 5-200 Myr. By searching a comparably large sample to previous studies but across a narrower age range, I explore the potential changes in the overall flaring activity for M5-G0 dwarfs, and the implications for star and planet formation.

Seiji Fujimoto
UT Austin

First ALMA Looks at the JWST High-z Sources at z=8-17

The advent of JWST has continues to yield innovative discoveries beyond our expectations in the studies of early galaxy formation and evolution. Imaging observations routinely report galaxy candidates at redshift frontiers, including several candidates now reaching out to z~17. Spectroscopic observations have detected numerous rest-frame UV to optical emission lines from early galaxies, allowing us to conduct their unprecedented characterizations. Following this momentum, multiple ALMA DDT observations have been conducted since July 2022. In this talk, I will review the latest DDT observation results for JWST high-z source, including my own 3 DDT programs, targeting a strongly lensed nascent galaxy at z=8.496 and a remarkably bright, ultra-high redshift galaxy candidate at z~17.

Pradip Gatkine
Caltech

Quest for High Resolution with Astrophotonic Spectrographs

Astrophotonics is a new system-on-chip approach for astronomical instrumentation to yield compact, modular, and novel ways to manipulate the photons from one or more telescopes on a chip. With their compact form factor, on-chip astrophotonic spectrographs offer a transformative approach for building ultra-high-resolution (R ~ 100,000) and high-stability spectrometers. Astrophotonic devices are critical for enabling some of the most exciting high-precision science cases, such as constraining exoplanet masses, atmospheres, and probing the multiphase galactic flows that enrich the universe with elements of life. In this talk, I will highlight novel strategies to build high-throughput on-chip astrophotonic spectrometers approaching R ~ 100,000 in the near-IR.

Mike Grudic
Carnegie Observatories

Why are stars?

The stellar initial mass function (IMF) and the nature of its variations have drastic consequences for nearly all aspects of astrophysics. Despite this importance, no comprehensive theory exists. The main barrier has been the physical complexity of star-forming clouds, resisting both analytic and numerical approaches. But a coherent picture of the physics explaining the IMF has begun to emerge in recent years thanks to a new generation of numerical simulations - from multiple groups - that are efficient enough to simulate the large dynamic range of star formation, while accounting for all of the key physics. I show how these results have helped us to explain 3 key aspects of the IMF: 1. why stars exist at all, 2. why massive stars are rare, and 3. why very-massive stars are very rare.

Thales Gutcke
University of Hawaii

Cosmological cluster formation and accretion in early-forming dwarf galaxies

I present a formation scenario for ancient globular cluster-like objects. The simulations model the formation of dwarf galaxies before Reionization and follow their evolution to the present day, during which they form 10^6—7 Msun in stellar mass. The model is taylored to include the necessary physics at this resolution scale. It features a multi-phase ISM, individual stars and resolved supernova. The clusters display dense stellar profiles, little DM and ancient SP. The SFH of each cluster is short and bursty, but some with multiple SP. The metallicity distributions are wide. This is possible beacuse these systems form in DM mini-halos at high-z, before the onset of Reionization. The DM is preferentially stripped as the clusters are accreted, with a mean accretion redshift of z~5.

Sultan Hassan
New York University

Implication of JWST constraints on UV luminosity density at Cosmic Dawn for 21cm

I will discuss the implications of the UV radiation background at cosmic dawn inferred by recent JWST observations for radio experiments aimed at detecting the redshifted 21-cm hyperfine transition of diffuse neutral hydrogen. Under the basic assumption that the 21-cm signal is activated by the Lya photon field produced by metal-poor stellar systems, I will show that a detection at the low frequencies of the EDGES experiment may be expected from a simple extrapolation of the declining UV luminosity density estimated at z ~14 by JWST early galaxy data. These findings raise the intriguing possibility that a high star formation efficiency at early times may trigger the onset of intense Lya emission at redshift z~18 and produce a cosmic 21-cm absorption signal 200 Myr after the Big Bang.

Marc Hon
University of Hawaii

The Great Escape of A Giant Planet from Planetary Engulfment

When main-sequence stars expand into red giants, they are expected to engulf close-in planets.The absence of planets with short orbital periods around red clump stars has been interpreted as evidence that close planets do not survive the red giant branch phase of their host stars. Here, I present the discovery of the 'forbidden' existence of a close-in exoplanet around a red clump star. As an unlikely survivor to its previously expanding host star, the planet may have avoided engulfment through a stellar merger of its host star that drastically altered the star's evolution. This is the first confirmed close-in planet around a red clump star and it provides evidence for the role of non-canonical stellar evolution in the extended survival of late-stage exoplanetary systems.

Ward Howard
University of Colorado Boulder

Constraining Exoplanet Atmospheres with Multi-wavelength Flare Campaigns

Although M-dwarf planets are favored targets for characterization, the frequent flares emitted by their host stars drive the composition of their atmospheres. Flares are multi-wavelength events where no single one fully describes the flare. I will discuss our ongoing flare campaign of 7 M-dwarfs of various masses, ages, and activity levels with data from the X-ray to the mm. I will then present the first analysis of NIR JWST spectroscopy of flares from TRAPPIST-1 during transits of rocky exoplanets. We model the line and continuum emission of the flares from 1-5 microns to discover that up to 80% of flare contamination can be removed from the transits, suggesting flare mitigation is a viable pathway to increase the impact of transit observations of small planets around active stars.

Sara Issaoun
SAO

Unraveling the Mysteries of Sgr A*

Last year, the Event Horizon Telescope collaboration revealed the first images of the shadow of our Milky Way supermassive black hole, Sagittarius A* (Sgr A*). Since its detection in the mid-70s, this bright radio source in the Galactic Center was shrouded in a veil of mystery. The EHT provided the first direct evidence that this object is indeed a black hole and resolved its shadow for the first time. In this talk, I will highlight ongoing projects to study the time-variability and origin of Sgr A*'s radio emission.

Mikhail Ivanov
IAS Princeton/MIT

Testing Dark Matter with Galaxy Surveys

I will present a new program of extracting cosmological information from large scale galaxy surveys. I will share some results of this program from my independent analyses of the public data from the Baryon acoustic Oscillation Spectroscopic Survey. Specifically, I will focus on new constrains on non-standard dark matter models.

Kartheik Iyer
Columbia University

Towards a self-consistent physical model for star formation in galaxies

Star formation in galaxies is regulated by a complex interplay of physical processes. I will present ongoing work using JWST observations and the CAMELS suite of cosmological simulations. Specifically: (i) applying the Dense Basis SED fitting to reconstruct the star formation histories of over 100k galaxies from CEERS and CANUCS, (ii) building a physically motivated analytical model (GP-SFH) for characterizing stochasticity in star formation rates, and (v) characterizing the impact of feedback on star formation using the CAMELS simulations. This will provide a new framework for understanding the physical processes that regulate star formation in galaxies, essential for developing robust models of galaxy evolution and interpreting observations from JWST and future telescopes.

Andres Izquierdo
University of Florida

Mining the kinematics of discs to hunt planets in formation

Detecting planets in their early stages of formation is key to reconstructing the history and diversity of fully developed planetary systems. I will present recent discoveries on the detection of potential planet-driven signatures in the circumstellar discs of HD 163296, MWC 480 and AS 209, using CO isotopologue emission observed at high resolution with ALMA. The study employs the Discminer modelling tool, which incorporates a statistical technique to identify localised deviations from Keplerian rotation in the gas disc—one of the most compelling indicators of potential planet presence. I will introduce the core capabilities of Discminer and demonstrate that a comprehensive study of line profile observables is indispensable for robustly detecting and characterising planet formation sites.

Nicholas Kern
MIT

New Insights on Cosmic Dawn Astrophysics from 21 cm Radio Telescopes

I will discuss the exciting but challenging prospect of tomographically mapping the intergalactic medium (IGM) at the Epoch of Reionization with 21 cm radio telescopes. Such a measurement will reveal the interplay between the first galaxies and their large scale environments, acting as a natural complement to rest-frame UV galaxy studies in the coming years. Recent progress in radio systematic modeling has allowed for improved upper limits on the 21 cm signal, yielding new insights into the physical state of the IGM at $z > 8$ and on the first generation of X-ray sources. I will further discuss new ML-accelerated approaches for robust systematics modeling and the path towards a first detection of the 21 cm signal at Cosmic Dawn.

Kyle Kremer
Caltech

Gravitational-wave and electromagnetic transients in dense star clusters

Over the past few years, the detections of gravitational waves from merging compact object binaries have opened a new window to the cosmos. However, the nature of the origin of these sources remains uncertain. Dynamical formation in dense environments like globular clusters has emerged as one formation channel, corroborated by numerical simulations and observational indications showing globular clusters contain myriad compact objects throughout their lifetimes. In this talk, I will discuss ways compact objects influence the evolution and observable properties of globular clusters, the formation of merging black hole binaries that are detectable via gravitational waves, and connections to other transient phenomena in globular clusters such as tidal disruption events and fast radio bursts.

Charles Law
University of Virginia

Chemical Signatures of Ongoing Planet Formation in Protoplanetary Disks

Planets form in dusty, gas-rich disks around young stars, while at the same time, the planet formation process alters the disk physical and chemical structure. ALMA observations of disks have revealed ubiquitous rings and gaps in their dust and molecular gas. While such features suggest the presence of embedded planets, it remains difficult to connect individual substructures with the location and properties of nascent planets. However, embedded planets are expected to locally heat the disk and sublimate volatile-rich ices and even shock nearby gas, which should cause detectable chemical asymmetries. In this talk, I will present recent ALMA observations of several such signatures linked to ongoing planet formation and discuss how they can be used to pinpoint and characterize young planets.

Calvin Leung
UC Berkeley

Fast radio bursts with CHIME/FRB Outriggers

The CHIME/FRB Outriggers project will add hundreds of sub-arcsecond FRB localizations to the existing sample of localized FRBs using very long baseline interferometry (VLBI). I will present an update on the status of the VLBI array, mainly focused on observations of bright continuum sources, pulsars, and FRBs using the Canadian Hydrogen Intensity Mapping Experiment (CHIME) and KKO, the first of CHIME's three FRB outriggers. KKO provides an angular resolution of ~1″ along one dimension; the resulting improvement in angular resolution over the CHIME/FRB baseband localization alone enables us to robustly associate host galaxies with our one-off bursts.

Matthew Liska

Georgia Tech

How do the most luminous black holes accrete and expel gas?

It is likely that most gas falls into supermassive black holes when the accretion rate approaches the Eddington limit (L=Ledd), at which point radiation pressure overcomes gravity. To date, our knowledge of such `luminous' black hole accretion disks mostly relies on semi-analytical models, supplemented by a very limited set of numerical simulations. In my talk I will discuss new insights gained from the first radiative general relativistic magnetohydrodynamics (GRMHD) simulations of luminous accretion disks. I will demonstrate that magnetic fields lead to the formation of a hot corona and that misalignment between the disk and black hole spin axis can explain quasi-periodic oscillations, which have remained a mystery for over 30 years.

Cassi Lochhaas

SAO

Simulated Galactic Accretion through the Circumgalactic Medium

The circumgalactic medium (CGM) is the boundary between galaxies and the rest of the Universe, so fresh gas that feeds star formation within galaxies must first flow through the CGM. Because this diffuse gas is difficult to observe, its properties and morphology are not fully understood. Using the cosmological zoom-in Figuring Out Gas & Galaxies In Enzo (FOGGIE) simulations that model the CGM at high resolution, I will show that accreting gas is primarily located in extended, cool filamentary structures that connect to the cosmic web. However, the filaments are disrupted by strong turbulence in the surrounding CGM diffuse gas before they can reach the galaxy. These simulation results provide context for planning and interpreting observations of accretion in the CGM.

Arianna Long
UT Austin

NIRCam Selected Quiescent Galaxies at $3 < z < 5$ in CEERS, COSMOS, and PRIMER

Most techniques for identifying massive quiescent galaxies in large photometric catalogs are tuned for the $z < 2$ Universe, where quiescent galaxies can be selected based on their red colors. At $z > 3$, this basis breaks down as quenching galaxies are bluer due to their younger ages. As a result, as much as 70% of quiescent galaxies at $z > 3$ may be missed. In this talk, I present a new empirical color selection technique designed to select massive quiescent galaxies at $3 < z < 5$ using JWST NIRCam imaging data. I apply this color selection criteria to the CEERS Survey, filtering out $>99\%$ of sources, and identify 44 candidate $z > 3$ quiescent galaxies. I will also share preliminary results on this technique as applied to the COSMOS-Web and PRIMER surveys.

Feng Long
University of Arizona

Revealing young planets from disk substructures

ALMA's unprecedented spatial resolution and sensitivity have recently transformed our understanding of planet-forming disks. Disk substructures, often appearing as bright and dark emission rings, have been detected in a large number of systems and are widely taken as the imprints of interactions between young planets and the disk material, thus crucial to identify key aspects of the planet formation process. Following the first detection of dust trapping in Lagrangian points in the LkCa 15 disk, which provides compelling evidence for the presence of young planet, I will report such new evidence in the DQ Tau disk. I will also present our recent efforts in exploring the emergence of disk substructures in the largely unexplored territories of small disks and disks around M-dwarfs.

Ryan MacDonald
University of Michigan

A JWST Spectrum of a White Dwarf Exoplanet

One day, the Sun will die. While the outer giant planets in our solar system will survive the death of the Sun, their long-term state is a matter of considerable uncertainty. Recent years have seen discoveries of exoplanets orbiting white dwarfs, which can provide a glimpse into the eventual fate of our solar system. I will present the first JWST observations of a planet orbiting a white dwarf: WD 1856b. Our spectroscopic observations, obtained during a planetary transit, offer dazzling insights into the evolutionary history and atmospheric chemistry of a post main-sequence exoplanet.

Hayley Macpherson
University of Chicago

Cosmological weak lensing in full general relativity

Measurements of weak lensing from galaxy surveys are vital in understanding our standard cosmological model. Galaxies cause distortions in the fabric of spacetime which bends light rays as they travel towards us. This effect is inherently general-relativistic, however, approximations within GR are typically used to make predictions from theory. Numerical relativity (NR) is a computational method used to solve Einstein's equations in full generality. We extract the lensing signal from NR simulations using ray tracing without making any approximations for gravity or geometry.Our signal thus represents the most general synthetic cosmological observation generated to date. Comparing our signal with widely-used approximations is imperative in ensuring accurate data analysis for future surveys.

Sinclaire Manning
UMass Amherst

SCUBA-Diving for JWST-Faint Dusty Galaxies in the First COSMOS-Web Release

Recent works have uncovered a subsample of dusty star-forming galaxies (DSFGs), characterized by non-detections in deep optical/near-infrared (NIR) surveys. These extremely dust-obscured and high redshift (z>4) “NIR-dark” DSFGs have been proposed to make up roughly 20% of all DSFGs and are proposed progenitors of z>3 quiescent galaxies. With JWST operational, we can now ask: are there JWST-dark galaxies? We present 8 “JWST-faint” DSFGs found in the first COSMOS-Web release identified via >4 sigma detections in both SCUBA-2 and ALMA data. Three of these galaxies exhibit exceedingly red colors and high redshift (z>5) estimates. We will discuss the physical properties of this heavily obscured population and contextualize them with other studies of NIR-dark galaxies.

Megan Mansfield
University of Arizona

The first spectroscopic eclipse map of an exoplanet

Exoplanet eclipse and phase curve observations have revealed information about energy transport and thermal structures of planetary atmospheres, but they have been fundamentally limited by the fact that these techniques only probe spatially-integrated fluxes. The launch of JWST in 2021 enabled the new technique of spectroscopic eclipse mapping, which is the only observational technique that can simultaneously resolve exoplanet atmospheres in latitude, longitude, and altitude. I will present an eclipse map of the ultra-hot Jupiter WASP-18b based on a secondary eclipse observation with JWST between 0.8-2.8 microns. I will describe two techniques used to map the atmosphere of WASP-18b and identify gradients in chemical and thermal properties across the dayside of the planet’s atmosphere.

Lea Marcotulli
Yale University

The most powerful persistent jets through cosmic time

About 10% of accreting supermassive black holes at the center of galaxies are capable of launching extreme relativistic jets. These AGNs and their jets have been studied for decades, from radio up to gamma-rays. However, many open questions still remain about the processes powering these powerful monsters. When, in the history of time, were the most luminous jets more numerous, and what is their connection with fast supermassive black-holes growth in the early universe? Are the radiating particles leptons or hadrons? Is the so-called 'blazar sequence' real or just a selection effect? In this talk, I will highlight how we can tackle some of these open issues through means of multiwavelegth studies, in particular exploiting the capabilities of current high-energy experiments.

Lia Medeiros
Princeton University

A Sharper Look at the Black Hole in M87

The sparse interferometric coverage of the Event Horizon Telescope (EHT) makes image reconstruction challenging. PRIMO is a new algorithm for image reconstruction that builds a principal components basis from high-fidelity general relativistic, magnetohydrodynamic simulations of accretion flows. This allows us to reconstruct images that are both consistent with the interferometric data and that live in the space spanned by the simulations. PRIMO can accurately reconstruct simulated EHT data sets for several simulated images, even when the simulations are significantly different from those of the image ensemble that was used to generate the basis. I will discuss the algorithm itself, its application to synthetic data, and show a new image of M87 published in April 2023.

Ariadna Murguia-Berthier
CIERA, Northwestern

Accretion onto Neutron stars: simulations of oblique rotators

There are many astrophysical scenarios where accretion onto a neutron star (NS) is expected, like ultra-luminous X-ray sources, and accretion-powered mili-second pulsars. In order to understand the emission of this sources, we need to simulate how matter is accreted onto the NS. Unfortunately, due to the need to simulate strong magnetic fields in general relativity, simulations are challenging. Simulations of a neutron star where the magnetic field is aligned with the rotational axis have been done in a self-consistent setup. In this talk, I'll discuss how we can use that setup and self-consistently add a tilt of the magnetic field. This simulations are state-of-the-art and can show us what happens when we study oblique rotators.

Rohan Naidu
MIT

Revealing the Protagonists of Cosmic Reionization with JWST

Reionization was the last great phase transition of the Universe, when the first sources of light transformed the vast reservoirs of cold, neutral gas across the cosmos into a hot, ionized state. The protagonists of cosmic reionization remain elusive. Was reionization driven by numerous, ultra-faint galaxies (``democratic reionization"), or by relatively rare, bright galaxies (the ``oligarchs")? Or did copious primeval black holes usher in this era? In this talk I will present results from my Cycle 1 JWST programs probing the first billion years at $z>6$, focusing on two surprises: (i) the remarkable ionizing power of bright, Small Magellanic Cloud-like systems; (ii) the ubiquity of "little red dots" in JWST images, which have proven to be an emerging class of infant black holes.

Joel Ong
University of Hawai'i

Asteroseismic Signatures of Post-Main-Sequence Planetary Engulfment

We report the discovery and characterisation of a rapidly-rotating red giant observed by TESS in its Southern Continuous Viewing Zone. The star's fast surface rotation is independently verified by the use of p-mode asteroseismology, strong periodicity in TESS and ASAS-SN photometry, and measurements of spectroscopic rotational broadening. Spectroscopic abundance estimates also indicate a high lithium abundance, among other chemical anomalies. These and other observational constraints suggest a planet-ingestion scenario for the origin of this rotational configuration.

Viraj Pandya
Columbia University

Galaxies Going Bananas: Inferring the 3D Shapes of High-Redshift Galaxies with JWST-CEERS

I will present surprising results on the 3D shapes of high-redshift galaxies based on JWST early release science observations. Using a novel differentiable Bayesian model with Hamiltonian Monte Carlo, I show that there are many more flat, elongated dwarf galaxies than there are round, circular dwarf galaxies seen in projection in the early Universe. This puzzle can be explained if a majority of high-redshift dwarfs are intrinsically prolate ellipsoids in 3D meaning that they are significantly flattened in two directions like a cigar. Alternatively, high-redshift dwarfs must be unusually oval (triaxial) disks. More massive galaxies are consistent with being normal oblate 3D ellipsoids (i.e., circular disks). I will discuss selection effects, follow-up prospects and theoretical implications.

Ekta Patel
University of Utah

Effects of the Large Magellanic Cloud on Orbits of Milky Way Satellite Galaxies

6D phase space measurements (3D position and velocity) derived from high-precision astrometric data is revolutionizing our ability to trace the orbital histories of nearly all known Milky Way (MW) satellites to their cosmic origins in the early Universe. However, until recently, orbital calculations relied on rigid halo potentials for the MW, excluding density perturbations arising from the passage of the Large Magellanic Cloud (LMC) through its halo. Using a time-dependent MW+LMC potential built from Basis Function Expansions of high-resolution MW+LMC simulations, we present first results from the Cranes project highlighting the effects of the LMC's dark matter wake, MW halo density perturbations, and LMC debris on the orbits of MW satellites with available 6D phase space information.

Sarah Pearson
New York University

Decoding Dark Matter with Stellar Streams from Beyond the Milky Way

Thousands of stellar streams will be observed in the halos of external galaxies with the Roman Space Telescope (Roman), Euclid, and the Vera Rubin Observatory. I discuss how stellar streams are sensitive to the distribution of dark matter and to the population of dark matter subhalos in galaxies, both of which depend on the mass and interactions of the dark matter particle. I demonstrate that just one radial velocity measurement breaks degeneracies between stream morphology and dark matter halo masses for external galaxies, and I show how Roman will be able to find stellar streams from globular clusters and their gaps from dark matter subhalo interactions out to 2-3 Mpc. This will open up a new era of statistical analyses of gaps in stellar streams and help constrain dark matter models.

Justin Pierel
STScI

Discovery of a Triply-imaged Type Ia Supernova at z = 1.78

The JWST PEARLS program discovered a triply-imaged Type Ia supernova (SN Ia) at z=1.78, which is is the first lensed SN Ia suitable for measuring the Hubble constant (H0). As all three SN images were visible simultaneously, the discovery epoch yielded 24 photometric samples (eight filters in three images). A follow-up DDT program yielded two further epochs in six filters, giving an unprecedented glimpse into a high-z SN Ia with an effective total of 60 photometric observations and three spectra (all three images in a single epoch). I will detail the results of light curve fitting including time delay measurements used for measuring H0, constraints on the lensing magnification, and tests for redshift-evolving luminosity using the standard candle nature of SNe Ia.

Emiel Por
STScI

High-performance coronagraphs for the Habitable Worlds Observatory

The Astro2020 Decadal Survey has endorsed the next NASA flagship mission, the Habitable Worlds Observatory (HWO). HWO will use high-performance coronagraphs and advanced wavefront control systems to directly image and characterize exo-Earths around Sun-like stars. Many types of coronagraphs exist today and the community is starting the down-selection process for HWO. I will present the latest results for the Phase Apodized Pupil Lyot Coronagraph (PAPLC), one of the candidates for the coronagraph on HWO, on the HiCAT testbed at STScI. Finally, I will present a novel coronagraph concept using integrated photonics to potentially achieve even higher performance. I will present its theoretical performance and tolerancing, and the path towards experimental verification.

Raluca Rufu
Southwest Research Institute

Origin of compact exoplanetary systems during disk infall

A surprising discovery in exoplanet science is the existence of compact systems of Earth to super-Earth sized planets orbiting within 0.01-0.1 AU from their star. While compact systems are common, their origin is debated. A prevalent assumption is that compact systems formed after the infall of gas and solids to the circumstellar disk ended. However, observational, theoretical, and meteoritical evidence suggests accretion may commence earlier. We propose that compact systems are surviving remnants of planet accretion during the end stages of infall.

Anowar Shajib
University of Chicago

Resolving the Hubble tension with strong-lensing time delays and the JWST

The most prominent challenge for the LCDM cosmology is the "Hubble tension," where the Hubble constant (H_0) measured using the Cepheid-calibrated cosmic distance ladder and that extrapolated from the CMB using the LCDM cosmology disagrees by 5sigma. To confirm new physics beyond the LCDM model as the source of this tension, ruling out any unknown systematic using another independent probe is crucial. Strong-lensing time delay is such an independent probe. To achieve high precision in H_0 with the time delays, spatially resolved stellar kinematics from IFU spectroscopy is essential to constrain the mass profile shape in the lens galaxies. I will describe how newly obtained and future upcoming data from the JWST will allow us to provide insights into the source of the Hubble tension.

Melinda Soares-Furtado
UW-Madison

Stellar Epitaphs: The Final Testimonies of Devoured Worlds

The phenomenon of planetary ingestion by stellar hosts has garnered considerable media attention over the past year, yet there is still much work to be done in identifying new engulfment-derived chemical tracers. In this talk, I discuss our team's ongoing work in uncovering instances where stellar hosts have ingested their planetary companions. I delve into our team's efforts to identify novel chemical tracers, which are indicative of such engulfment events within these systems. Through these investigations, we aim to enhance our understanding of the phenomena surrounding planetary ingestion and refine our ability to detect its signatures.

Jessica Spake
Caltech

Tails of escaping exoplanet atmospheres

No planetary atmosphere is eternally fixed. They are subject to mass loss, interior heating, stellar winds, and magnetic fields, among other disturbances. As they age, their compositions change; so do their sizes. The change must be quantified - firstly, to explain enduring mysteries in the distribution of exoplanet radii (what caused the hot Neptune desert? Why are some planets over-inflated?), and, eventually, to know which exoplanets retain habitable atmospheres for billions of years. To advance these aims, I develop new ways to measure change in exoplanet atmospheres. I will outline a path to better planetary- and stellar mass-loss measurements using observations of hydrogen and helium in the comet-like tails of escaping atmospheres.

Gudmundur Stefansson
Princeton University

A close-in Neptune orbiting an ultracool star

In current theories of planet formation, close-orbiting planets as massive as Neptune are expected to be very rare around low-mass stars. We report the discovery of a Neptune-mass planet orbiting a nearby `ultracool' star which is nine times less massive than the Sun. The planet's orbital period is 3.7 days and its minimum mass is 13.2 Earth masses, giving it the largest known planet-to-star mass ratio among short-period planets (<100 days) orbiting ultracool stars. Both the core accretion and gravitational instability theories for planet formation struggle to account for this system. In this talk, we place this surprisingly massive planet in context of the other known planetary systems known to orbit ultra-cool stars.

Wren Suess
Stanford University

A JWST view of massive quiescent galaxies at cosmic noon

JWST galaxies: it's not all z>8! In this talk, I'll present some recent results from JWST imaging of massive quiescent galaxies around cosmic noon, 1<z<3ish. I'll go over new long-wavelength insights into their sizes, then present a newly-discovered population of low-mass companions that were invisible in previous HST imaging. If time permits I'll also give a preview of my upcoming JWST Cycle 2 program "Medium Bands, Mega Science" which will image the region around Abell 2744 with all dozen of JWST/NIRCam's medium-band filters.

Jiayi Sun
Princeton University

A Multiwavelength View of Star Formation across the Local Universe

I will showcase recent advances in understanding star formation across large samples of local galaxies. These advances are enabled by state-of-the-art observations with ALMA, VLT, and HST, which discern fundamental units of star formation. We find that molecular clouds, which set the initial condition of star formation, are strongly coupled to the large-scale properties of their host galaxy. Once star formation takes place, feedback from young stars quickly disperse the natal cloud, resulting in an overall low star formation efficiency. While this process is highly non-equilibrium on 10-100 pc scales, star formation appears self-regulated via stellar feedback over kpc scales. I will conclude with an outlook on the new possibilities JWST is bringing to us.

Maggie Thompson
Carnegie EPL

Simulating Young, Rocky Planets in the Laboratory

We are in an exciting new phase of exoplanet science in which we are now beginning to characterize the physics and chemistry of low-mass, rocky exoplanets. In preparation for this upcoming observational data, we need a comprehensive understanding of the formation history, bulk composition and atmospheric properties of rocky planets. To inform the connection between rocky planets' interior compositions and their early atmospheres, I will present several experimental techniques to measure the outgassing compositions and volatile solubilities of planetary analog materials under a range of temperatures, pressures and atmospheric redox states. These experiments will provide new ground-truth information on the thermal decomposition, release and retainment of volatiles for rocky exoplanets.

Jake Turner
Cornell University

The ongoing hunt to detect exoplanetary magnetic fields

One of the most important exoplanetary properties is not yet directly detected despite decades of searching: the presence of a magnetic field. The knowledge of an exoplanet's magnetic field will provide valuable insights into its interior structure and atmospheric escape. Two promising methods (radio observations and spectropolarimetry of the helium line) have been proposed to study exoplanetary magnetic fields. In this talk, I will discuss our extensive multi-year multi-site follow-up campaign to confirm the first possible detection of an exoplanet in the radio, our ongoing campaign observing a hot Jupiter in spectropolarimetry for the first time, and the preparatory work being done for future large space-based radio telescopes.

David Vartanyan
Carnegie Observatories

Supernovae: From Bounce to Breakout

Simulations of core-collapse supernova (CCSNe) took consecutive leaps of progress in the last decade. The neutrino-driven mechanism produces robust explosions in detailed, three-dimensional radiation-hydrodynamic simulations and provides the liberty to pursue simulations with greater confidence. Motivated by these results, I present a series of developments: I provide late-time neutrino data for 100 axisymmetric simulations; showcase a new, two-dozen model suite of 3D simulations; illustrate an exotic - perhaps not uncommon - joint formation of a black hole with an exploding CCSNe; and finally, portray early simulations that couple core-bounce and explosion to shock breakout. These efforts are designed to buttress a more intimate connection between supernova theory and observations.

Maria Vincenzi
Duke University

SN Cosmology from the Dark Energy Survey

The Dark Energy Survey SN sample is the largest and deepest SN sample to date. It includes 2000 photometrically identified SNe Ia with high-quality multi-band light curves and spectroscopic redshifts, 15% of which are spectroscopically confirmed thermonuclear supernovae. With a redshift range between 0.1 to 1.2 and a well-defined selection function, this SN sample constitutes an ideal dataset for cosmological analysis. In the talk, I will give an overview of the cosmological analysis of the DES SN sample and present preliminary constraints on cosmological parameters.

Luis Welbanks
Arizona State University

Swimming Through New Chemical Species in Exoplanetary Atmospheres with JWST

In this presentation I will share results from different JWST programs characterizing the atmospheres of exoplanets. Executed within the first year of JWST operations, some of these results have significantly expanded our knowledge about the atmospheric chemistry and evolution of exoplanets. We detect and constrain several chemical species that were previously elusive in exoplanetary atmospheres, including methane (CH4), sulfur dioxide (SO2), carbon monoxide (CO), and carbon dioxide (CO2), alongside several precise water (H2O) measurements.

Michael Wong
Carnegie Institution for Science

A natural law of evolving systems and a novel in-situ biosignature technique

This year, I will cover two new papers regarding evolving systems. In the first, we identify conceptual equivalencies between evolving systems and propose a time-asymmetric law that states that the functional information of a system will increase over time when subjected to selection for function. A prediction of this proposed law is that biological systems should exhibit distinctive features due to extensive selection for function. In the second paper, we develop a novel, spaceflight-ready, in-situ biosignature technique that combines py-GC-MS measurements with machine-learning classification to achieve ~90% accuracy—a significant advance for astrobiology. Such discrimination points to underlying "rules of biochemistry" that reflect the imperative of biomolecular selection for function.

Jessica Zebrowski
University of Chicago

Commissioning Strategy of SPT-SLIM

Dark energy, the mysterious force that drives the accelerating expansion of the universe, is one of the unexplained mysteries in cosmology. To understand the potentially evolving nature of dark energy we have to probe the gap between measurements of the early Universe as traced by the cosmic microwave background 13 billion years ago and the Universe as we see it now through galaxy surveys, by making measurements of the years in between. New technology is reaching maturity to enable a new technique, Line Intensity Mapping (LIM) that would be able to probe these yet-unmeasured middle ages, to map from now back to 11 billion years prior. In this talk, I will describe the testing, integration, and deployment strategy for mm-wave spectrometers on the South Pole Telescope as a LIM pathfinder.

Zhoujian Zhang
UC Santa Cruz

Probing the formation of gas-giant exoplanets via atmospheric composition

Measuring and comparing the elemental abundances of directly imaged exoplanets and their host stars provide valuable insights into planet formation pathways. In this talk, I will introduce a large spectroscopic survey that uniformly measures atmospheric composition for all known directly imaged exoplanets, benchmark brown dwarfs, and their host stars. Focusing on a recently discovered imaged planet, I will present an in-depth analysis of both the planet's and its host star's atmospheric properties, as well as the system's orbital architecture. Our novel atmospheric retrieval framework, developed for characterizing cloudy self-luminous atmospheres, reveals the potential metal enrichment of the planet, likely resulting from late-stage planetesimal accretion or giant impact.

Jon Zink
Caltech

Hot Jupiters. Are They Alone?

I will present a captivating study focusing on the population characteristics of gas giants with orbital periods less than 10 days, commonly known as hot Jupiters. Despite being the first class of exoplanets discovered, they lack a solar system analog and remain enigmatic in their origin. Our research reveals that systems with gas-giants often host more than one, similar to multiplicity seen in our own solar system. However, we have found that companionship alone is not enough to explain the formation or evolution of short-period gas giants. Our talk culminates in identifying two pivotal factors crucial for the production of hot Jupiters: the presence of two gas giants, with the outermost planet being significantly more massive and having a heightened eccentricity.