Session M Abstracts

Quality assessment of skydata from the OVRO-LWA radio telescope
Aaron W. Chan
Mentors: Gregg W. Hallinan and Nivedita Mahesh

The Owens Valley Radio Observatory Long Wavelength Array (OVRO-LWA) operates at low frequencies approximately from 13MHz to 82MHz, and captures images of the sky at various times throughout the day. However, these sky images can be distorted and inaccurate due to charged particles in the ionosphere interfering with the radio waves being captured by the array. This is one of the issues we hope to fix. While existing data from the OVRO-LWA can be used for data analysis, there is no streamlined way to create images from the captured data. Using Python with Jupyter, in addition to numerous Python libraries, we aim to create a program to efficiently bridge the gap between telescope data stored in directories and the individuals who analyze the generated sky images. The completion of this project will allow for improved OVRO-LWA data analysis by providing a program to easily generate sky images from OVRO-LWA data. Additionally, this project enables future opportunities such as a program for pattern recognition or predicting trends in subsequent data sets.

Modeling and simulation of antennas for absolute flux measurements in early cosmology
Yanfen Lin
Mentors: Gregg W. Hallinan and Nivedita Mahesh

One of the most significant open questions in astrophysics is understanding the Cosmic Dawn—the era approximately 50 million to one billion years after the Big Bang during which the first stars, galaxies, and black holes emerged. The best way to study this period is by detecting the highly redshifted 21-cm signal emitted by neutral hydrogen. This project focuses on modeling and simulating broadband antennas for absolute flux measurements to aid in detecting this faint radio signal. Using CST Studio Suite, we developed and analyzed MANAS (Measuring Antenna Neutral-Hydrogen Signal), a monopole discone antenna operating from 30–100 MHz. We investigated antenna performance metrics including gain, reflection coefficient (S_{11}), and beam response to identify the optimal design, providing guidance to the team during antenna construction and answering key design questions.

Investigating the HD 984 system with the Keck Planet Imager and Characterizer
Anica J. Ancheta
Mentors: Dimitri P. Mawet and Katelyn Horstman

Different types of substellar companions, such as brown dwarfs and planets, have different formation pathways. Investigating these pathways is key to understanding how these objects form, and therefore understand if our own solar system possesses unique conditions to support life. HD 984 A is a 1.2 solar mass F7V star known to host a hot brown dwarf companion, HD 984 B, previously imaged with the Keck Planet Imager and Characterizer (KPIC) between August 2022 and November 2024. This project investigates the possibility of a second brown dwarf in the HD 984 system, which could classify the system as a brown dwarf binary (BDB). We leverage KPIC's unique capabilities of combining direct imaging and high-resolution spectroscopy (R ~35,000) over multiple epochs of data, and utilize the KPIC data reduction pipeline in conjunction with the Broad Repository for Exoplanet Analysis, Detection, and Spectroscopy (BREADS) to extract radial velocities over time. Through cross correlating spectra with models and modeling orbital solutions, we look for the presence of a second substellar companion.

Cloud watching in the simulated circumgalactic medium
Cecilia K. Abramson
Mentors: Lars Hernquist, Cameron Hummels, and Scott Lucchini

The circumgalactic medium (CGM), the diffuse halo of multiphase gas surrounding the galaxy, is crucial for regulating accretion and feedback processes. Despite temperatures reaching ~10^7 K within the CGM, cool clouds (<$10^{4.5}$ K) could play a key role in renewed star formation. However, due to small scale structure, studying these clouds in hydrodynamical galaxy simulations is difficult. We utilize the new cosmological zoom simulation suite, ENhanced Galactic Atmospheres with Arepo (ENGAWA) with IllustrisTNG physics to study a Milky Way-like galaxy at four different resolutions, including the highest resolution of 200 pc within the inner CGM. Through analysis of how temperature, metallicity, and other properties shift across the cloud boundary layer, we present an improved understanding of the transition between gas within the cloud and the surrounding medium. We quantify the differences in these cloud-centric radial profiles as a function of cloud size, as well as resolution, to better understand the effect of these variables on gas mixing around galaxies.

Turbulence! A multi-scale investigation into the dynamics of the circumgalactic medium around UGC 7342
Maria J. Sanchez Rincon
Mentors: Mandy Chen and Charles C. Steidel

The circumgalactic medium (CGM), the outermost nebulous part of a galaxy, can reveal information about the dynamics and turbulence present in the gases of a galaxy. UGC 7342, a galaxy in the Coma Berenices constellation, has little to no constraints on its dynamics within the circumgalactic medium. Mapping these motions can lead us to information on galaxy growth and evolution. The 2020 Decadal Survey of astronomy called ”unveiling the drivers of galaxy growth” a priority area in astrophysical research. For this project, we are focusing on mapping the brightness of [OIII]λ5008, [NII]λ6584, H-alpha and H-beta emissions, measuring the velocities of the [OIII]5008 emission, plotting the Baldwin, Phillips Telervich (BPT) Diagram, and probing the gas dynamics with velocity structure functions (VSFs). Through analyzing the velocity structure functions, we can infer and constrain the type of turbulence present, along with the scales at which kinetic energy is injected and dissipated in the form of heat. These results will shed light on how intertwined different areas of various scales in galaxies are, no matter their separation and scale.

Disruption of resonant-chain planetary systems
Diya T. Kumar
Mentors: Fei Dai and Lynne Hillenbrand

Type-I disk migration can capture planets into chains of mean-motion resonances (MMRs) at the inner edge of the protoplanetary disk, including higher-order MMRs that have been observed in young planetary systems despite their weaker dynamical strength. Observationally, ~90% of young systems host at least one resonant planet pair, but this fraction declines sharply with age - dropping to ~40% for adolescent systems and ~20% for mature systems - indicating that resonant chains are disrupted over time. Previous work has shown that Type-I migration can produce both first-order and higher-order resonances, with second-order (e.g. 5:3) and third-order (e.g. 5:2) configurations forming through the breaking of pre-existing first-order resonances. In this work, we take these resonant chains from multi-planet migration simulations and evolve them forward through a phase of disk dissipation and ultimately integrate them for 1 GYR to investigate their long-term stability. This work will contribute to characterizing the dynamical pathways and timescales by which resonances break, and to assess how various characteristics of the resonant chain influence its survival. The results will help interpret the observed decline of resonance over time and connect the architectures of young, resonant chain systems to their final configurations in older planetary systems.

Evaluating late-time nebular spectral features for progenitor mass in stripped-envelope supernovae

Athiwat N. Ackaramongkolrotn
Mentors: Mansi M. Kasliwal and Kaustav Das

Determining the progenitor masses of supernovae are crucial to understanding the processes that underlay their formation. Of particular interest are stripped-envelope core-collapse supernovae (SESNe), which have their hydrogen and/or helium layers stripped. Two methods are currently in use to determine their progenitor mass: a correlation between the ratio of [O I] $\lambda\lambda$6300, 6364 and [Ca II] $\lambda\lambda$7291, 7323 and the kinetic energy of the explosion, and a fitting using the fractional flux of the [N II] $\lambda\lambda$ 6548, 6583 line. However, these methods have only been tested in models and small sets of supernovae, meaning a more comprehensive approach is needed. By comparing these methods on a large database of supernovae, we find that the [O I]/[Ca II] method is more consistent and applicable towards a larger range of spectra, while the [N II] method is only applicable to a smaller set of supernovae and has less reliable results.

The fast and the furious: Explosion properties of faint stripped-envelope supernovae from the Zwicky Transient Facility

Nikhita Penugonda
Mentors: Mansi M. Kasliwal and Kaustav Das

Stripped-envelope supernovae (SESNe) are a subclass of core-collapse supernovae characterized by the loss of their outer hydrogen and, in some cases, helium layers prior to explosion. This study investigates the photometric properties of SESNe identified in the Zwicky Transient Facility's Census of the Local Universe (CLU) survey, the largest systematic survey of SESNe to date, with a particular focus on low-luminosity objects. Light curves for over 600 SESNe candidates were modeled using Gaussian Process regression to extract key features, including peak absolute magnitude, explosion epoch, rise and decline timescales, and luminosities in the *g*- and *r*-bands. The resulting distributions indicate that these transients exhibit a rise time of $11.26^{+3.28}_{-2.31}$days, a decline time of $15.68^{+5.53}_{-3.17}$days, and a peak absolute magnitude of $-17.47^{+0.69}_{-0.50}$mag in the *r*-band. These parameters will be used to infer the mass of synthesized Nickel-56, a key driver of luminosity in core-collapse supernovae. This analysis aims to parametrize explosion physics and progenitor characteristics of SESNe, contributing to a deeper understanding of their role in stellar evolution and galactic chemical enrichment.

YSN-Class (Young SuperNova Classifier)

Oleksandra Pyshna
Mentors: Mansi M. Kasliwal, Ashish Mahabal, and Wynn Jacobson-Galan

We present YSN-Class (Young SuperNova Classifier), a multi-modal supernova classifier with emphasis on early-time observations (e.g., < 1 week post-explosion). Presently, YSN-Class combines two modalities (optical photometry and spectra) with varying representations and features in a fusion architecture. Our classifier is trained and tested on a sample of 2242 supernovae from the Census of the Local Universe (CLU) survey, a volume-limited, spectroscopically-complete Zwicky Transient Facility (ZTF) sample. Currently, in photometric classification mode, YSN-Class scores 85% in the weighted accuracy metric and has an average F-1 score of 72% for three supernova classes (Ia, II, and Ib/c) and with data at <5 days since the estimated explosion date. In addition, YSN-Class can sub-classify type II supernovae into two classes: "flash features" and "no-flash features", which are used to identify observational signatures of interaction between supernova ejecta and confined circumstellar material, getting a 73% average F-1 score based on photometry that covers maximum supernova brightness. YSN-Class is a promising way of classifying supernovae with ZTF, which can be combined with the upcoming Vera C. Rubin Observatory (VRO) transient detection alert stream and existing real-time classification pipelines in order to provide a robust classification within the first ~days since explosion.

Characterizing WISEA J064750.85-154616.4, a new L/T transition binary system
Ethan A. Alderete
Mentors: Trent Dupuy and Andrew W. Howard

Brown dwarfs cool over time, evolving through distinct spectral types. The transition from L-type to T-type is of particular interest due to its rapidity and poorly understood physical mechanisms. We aim to provide more insight into these processes by quantifying the physical and spectral characteristics of WISEA J064750.85-154616.4 (J0647), a binary whose components lie near or in this transition. Direct images of J0647 were taken by the Near-infrared Camera, Second Generation (NIRC2) instrument on the Keck Observatory between 2015 and 2024. By reducing these images, we obtain Separation and Position Angle measurements in milliarcseconds and degrees, respectively. We use the open-source Orbits from Radial Velocity, Absolute, and/or Relative Astrometry (orvara) Python package on those measurements to obtain an orbit profile of J0647, containing physical parameters such as the orbital period and total dynamical mass. Using absolute astrometry measurements from the Wide-field InfraRed Camera (WIRCam) Canada-France-Hawaii Telescope (CFHT), we find the binary's parallax and proper motion; combining this with the orbit fit from orvara, we calculate the individual masses of each companion and other physical parameters. In addition to imaging analysis, we have a total spectrum of J0647, obtained from the Keck Observatory. As Keck's spectrometer cannot resolve the binary's components, we estimate the individual spectra using a reduced Chi-Squares technique which attempts to re-create the total spectrum of J0647 from binary addition of single spectra taken of field brown dwarfs. We intend to use these new-found physical and spectral properties to test the efficacy of different brown dwarf evolutionary models, thereby helping understand what may lead to and cause the brown dwarf L/T transition.

Efforts toward precise stellar characterization for Keck Planet Finder spectrographs
Veronika C. Voss
Mentors: Andrew W. Howard and Luke Handley

The accurate characterization of stellar properties (such as effective temperature, surface gravity, metallicity, and rotational velocity) is essential for understanding the structure and evolution of planetary systems. These stellar parameters influence key measurements like planetary radius, mass, and orbital dynamics. Traditionally, determining these stellar parameters requires a detailed analysis of the stellar spectrum on a system-by-system basis. The Keck Planet Finder (KPF), with its high-resolution and high signal-to-noise capabilities, presents a powerful opportunity to automate this process. Our research aims to develop an automated algorithm that can estimate stellar properties from KPF spectra by interpolating through a catalog of well-known systems. Inspired by a proven algorithm for an older generation spectrograph, our method is designed to operate efficiently across a broad range of stellar types and spectral features due to the wide bandpass and high resolution of the new instrument. Once complete, the algorithm will enable rapid, reliable characterization of stars observed by KPF. The algorithm is currently under development, and a spectral library is being constructed. We are exploring several new data reduction steps for calibrating the library, which are not yet in the standard instrument pipeline. The algorithm will be deployed on all past and future KPF observations, robustly calculating the spectral properties of thousands of stars and enhancing our understanding of at least that many planets.

Anomaly detection in astrophysical time series using recurrence plots
Mariana Vale Taveira
Mentors: Matthew J. Graham and Kira Nolan

Large time-domain surveys, such as the Zwicky Transient Facility (ZTF), produce extensive time series datasets that frequently include rare or unanticipated patterns of variability. Identifying such anomalies can point to new astrophysical phenomena, yet this task is complicated by the irregular sampling that characterizes many observations. In this work, we investigate recurrence plots (RPs) as a framework for representing and quantifying the dynamical structure of astrophysical time series, with the objective of enabling automated anomaly detection. We constructed a processing pipeline to generate high-resolution RPs from both synthetic and real ZTF active galactic nuclei (AGN) light curves. The synthetic set spans a range of stochastic and deterministic signal types, and is used to train a convolutional Siamese network with contrastive loss to learn a similarity metric directly from

RP images. Real AGN light curves are regularized and embedded using parameters optimized through data-driven methods before RP computation. The trained network then compares pairs of RPs to build a dissimilarity matrix, from which candidate outliers can be identified. This combination of recurrence analysis and deep metric learning is designed to retain the interpretability of the RP representation while scaling to large datasets. Although developed for AGN light curves, the approach is applicable to other classes of astrophysical time series.