2022 Astrofest Abstracts

ORAL PROGRAM

How federal agencies fund innovation and how you can be involved - Rukmani Vijayaraghavan, U.S. Department of Energy (Invited)

If you are an astronomy researcher, your work is very likely funded by the federal government. From my perspective at the U.S. Department of Energy, I will provide some insights on how we as part of the federal government develop short-term and long-term strategies to fund research & development (and in applied energy, deployment and demonstration further along the spectrum), and the variety of funding opportunities like prizes and grants that we use to incentivize different stages and types of research at universities, National Labs, and the private sector. I will also talk about how you can get involved -- as a citizen, as a researcher influencing federal innovation policy, and if you're considering the federal government as a future career.

A Characteristic Optical Variability Timescale in Astrophysical Accretion Disks - Colin Burke

Stochastic variability in active galactic nuclei (AGN) hosting supermassive black holes is ubiquitous across wavelengths and timescales. A key question is if AGN variability properties can be related to physical properties of the accretion disk. In this talk, I will show our recent results demonstrating the characteristic “damping” timescale of AGN light curves correlates strongly with the mass of the black hole across the full range of supermassive black hole masses (10^4 — 10^10 Solar Masses). To overcome the challenges associated with making these measurements, we used high-quality ~20 year long light curves from a variety of surveys plus dedicated AGN monitoring programs. Comparison with microlensing measurements of AGN accretion disk radii indicates the damping timescale is the thermal timescale at the radius of UV emission. These findings will enable black hole mass estimation using Rubin Observatory light curves, and opens a new window into studying the accretion phenomena. Extension to stellar-mass accretion disks suggests the interpretation may be universal, and could be a powerful new tool for identifying the elusive intermediate mass black hole population.

Protoplanetary Disk Polarization at Multiple Wavelengths: Evidence for Diverse Dust Populations - Rachel Harrison

Dust polarization has been observed at (sub)millimeter wavelengths in an increasing number of protoplanetary disks. Multiple mechanisms could theoretically produce this polarized emission, including the alignment of non-spherical dust grains to the magnetic field or radiation anisotropy, aerodynamic alignment, or self-scattering. Multi-wavelength polarization observations are necessary to distinguish between these mechanisms, and to extract information about dust properties from the polarized emission. We present observations of linear polarization in five Class II protoplanetary disks at 3 mm and 870 μm, showing that polarization spectra can vary between otherwise similar disks. For the disks whose polarization morphologies are consistent

with scattering, we compare the data to models of scattering polarization for several different dust grain populations. We discuss possible origins of the differences in the sources' polarization spectra, including differences between their dust populations.

Threat Assessment of X-rays from Supernova Explosions - Ian Brunton

The potentially hazardous effects of supernova (SN) explosions on terrestrial-like atmospheres have been widely studied in the last 20 years. Much of this research has focused primarily on the atmospheric damage from high-energy cosmic rays and gamma rays promptly emitted in the explosion. In this study, we turn the focus to persistent high-energy X-ray emission observed months and/or years after the initial outburst of certain SNe, thought to arise from interactions with a dense circumstellar medium. The influence that SN X-rays have on habitability has previously been overlooked, likely as a consequence of scant observational datasets in the X-ray band. Within the last few decades, however, more sensitive X-ray telescopes, notably Chandra, Swift-XRT, and NuStar, have enabled a more robust understanding of SN X-ray output. We use these modern datasets to conduct a risk analysis that sits within the context of the previous literature on SN terrestrial influence. We conclude that the X-ray energy outputs associated with Type IIn SNe and certain Fast Blue Optical Transients (FBOTs) have significantly larger "kill radii" than ordinary SNe. These events, while rare, pose a substantial threat to terrestrial-like radiation environments and may impose additional constraints on the Galactic habitable zone.

Search for exoplanet candidates in TESS data - Jamila Taaki

We apply prior work on a joint signal modelling and transit detection to search for exoplanet candidates in the first 3 years of TESS 2 minute cadence lightcurves. This method works on unprocessed lightcurves which contain significant instrumental systematics that may otherwise conceal transit signals.

CAPS: Center for AstroPhysical Surveys - Joaquin Vieira

I will present an overview of the Center for AstroPhysical Surveys (CAPS) at the National Center for Supercomputing Applications (NCSA). I will discuss the mission, current activities, and future goals of CAPS, with an emphasis on local opportunities for students, postdocs, and faculty.

POSTER PROGRAM

A Close Quasar Pair in a Galaxy Merger at z= 2.17 - Tony Chen

Distinguishing dual quasars from lensed quasars at high redshift is challenging using only optical imaging and spectroscopic techniques, because both sources have similar spectral properties. We present a comprehensive multi-wavelength analysis of a 0.5 arcsec z=2.166 dual quasar system, J074922.96+225511.7, which was selected using a new “Varstrometry” technique. The HST and Keck adaptive-optics NIR images reveal the non-detection of the lens galaxy and the faint tidal features. The flux ratios between two sources in the X-ray and radio images are significantly different than those in the optical images. These results suggest that J074922.96+225511.7 is a dual quasar, instead of a lensed quasar. We find that J074922.96+225511.7 is a dual quasar with the smallest projected separation of any known dual quasar at z>1. This discovery demonstrates the effectiveness of the “Varstrometry” technique for systematically detecting kpc off-nucleus and dual quasars at cosmic noon.

Outreach at the Horizon: Exploring the Past, Present, and Future of Event Horizon Telescope Outreach Endeavors - Nick Conroy

The next generation Event Horizon Telescope (ngEHT) has tremendous potential to engage the public in astronomical research. People are particularly fascinated by black holes: an unprecedented 4.5 billion people are said to have seen the first image of a black hole, released by the EHT on April 10th, 2019.1 Through black hole photographs and movies that can seamlessly transition into outreach content, the ngEHT is uniquely situated to succeed in its outreach endeavors. This outreach work is critical. During the early stages of the pandemic, almost 40% of Americans said they would refuse a COVID-19 vaccine if it were offered to them.2 Last term, 30% of the United States Congress denied the very existence of human caused climate change.3 Science denial and insufficient support plagues almost all STEM fields, stymying funding for scientific research and crippling our ability to solve major societal problems. Through a diverse array of outreach projects, the EHT has fought to improve scientific literacy and engagement, championing the necessity of scientific research driven by international collaboration. Much of its outreach was online. The implementation of a new social media strategy has increased its total Instagram content by 6x and drove total online subscriber numbers up by 8.6%. The slew of recent science documentary style videos has accumulated almost 200,000 views. Its recent press releases have generated 100s of online articles in over 20 languages. Other efforts focus on in-person outreach. Live presentations are quite popular, and give interested members of the public a chance to directly engage with EHT scientists. We are currently developing EHT museum exhibits and classroom content, offering the opportunity to educate millions of people about EHT science in great detail. This bounty of EHT outreach projects not only underscores the great potential of ngEHT outreach, but it provides key lessons about how collaborations can conduct successful outreach. Ultimately, by prioritizing a diverse array of outreach projects, the ngEHT can leverage its unparalleled potential to engage, educate, and inspire millions and even billions of people across the planet.

Incorporating the Donor Star Response in 1D Simulations of Common Envelope Evolution - David Cruz Lopez

In order to analyze the evolution of a common envelope (CE) consisting of a neutron star (NS) and main red supergiant (RSG), we used the stellar code MESA to evolve the RSG at each differential timestep in our 1D inspiral model. Included is the RSG response to the drag energy injection experienced from the neutron star in its envelope. We have modeled the CE to include the feedback from the NS jets to observe its mass accretion rate and determine if the envelope will remain bound.

AT 2020nov: Investigating the Luminous End of a Tidal Disruption Event - Nicholas Earl

The death of stars can be spectacular events, providing a plethora of information about the star itself and the local environment. In rare circumstances, a star's trajectory can take it within the tidal radius of a supermassive black hole, where the tidal forces tear apart the stellar structure of the star in a phenomenon called a Tidal Disruption Event (TDE). These unique occurrences result in luminous, transient flaring and reveal characteristics of not only the star but also the black hole, which is especially useful in cases where the black hole may not be active enough to observe otherwise. We present a photometric and spectroscopic analysis of the 2020nov tidal disruption event, a new TDE observed as part of the Young Supernova Experiment (YSE) transient survey. From the photometric data, we have modeled the rise to peak and the long-term evolution of 2020nov, providing characteristics on the black hole and stellar masses, along with the impact parameter of the event. The spectroscopy reveals two-component Balmer profiles, indicative of reprocessing of emission from an accretion disk. We then perform a time-lag analysis to determine the blackbody radius of a potential reprocessing layer.

Local and Global Environmental Effects on Boundedness in LMC Clouds - Alex Green

The effects of feedback in molecular clouds are still not well understood. To investigate the effect of such mechanisms on the gravitational state in clouds, we study CO and 13CO ALMA maps of 9 molecular clouds distributed throughout the Large Magellanic Cloud. We perform noise and resolution matching on the sample, with a common resolution of 3.5" (0.9 pc at the LMC distance of 50 kpc) and use the SCIMES clustering algorithm to identify discrete substructure, or "clumps". We supplement these data with resolution-matched Spitzer IRAC 8 micron maps, which trace recent star formation. The clumps identified cover a range of 1-10^5 solar masses in luminous mass and 1-10^2 MJy/sr in average 8 micron surface brightness. We use cloud- and clump-scale properties to investigate additional dependence to relationships such as Larson's laws. We find that CO clumps exhibit a correlation between clump-averaged 8 micron and excess non-thermal line width while 8 micron is not well correlated with CO surface brightness. In 13CO clumps we also find a trend between 8 micron and excess non-thermal line width. Our analyses give insight towards the effects of local heating on clump boundedness.

A simple embedded subgrid model for black hole accretion disks - Ferzem Khan

Mass accretion plays an important role in many active phenomena such as star formation, interacting binary stars, quasars and radio galaxies. Black hole accretion disks have been studied and modeled extensively in the past decades, shedding light on the physical conditions of the accreting gas. We study the conditions under which the accretion disk can be hot or cold, and the underlying equations that dictate the structure of the accretion disk. We develop a simple Python program that models a one-dimensional, axisymmetric accretion disk around a black hole, and find the radial profiles of density, temperature and other properties of the disk analytically assuming self-similarity. Our code models the accretion disk as either an optically thick Shakura-Sunyaev disk (SSD), an optically thin advection-dominated accretion flow (ADAF), or a hybrid model with a transition from an outer SSD model to an inner ADAF. We find the transition radius between the models given the black hole mass, accretion rate, viscosity parameter, and mass outflow parameter. We also study the time evolution of our model for different imposed accretion histories.

iADD: Illinois Astrophysical Dynamics Demos - Sean Lee, Rayna Spencer

iADD (Illinois Astrophysical Dynamics Demos) is an interactive website allowing visitors to learn about numerical simulations in different areas of astrophysics, such as stellar evolution, galaxy mergers, and star formation. One section displays movies showing results of precomputed simulations, while another allows visitors to run their own simulations from the browser. We describe iADD's basic features as well as two new modules we are developing. The first uses the MESA stellar evolution code to simulate interacting binary stars and produce a movie showing their joint evolution. The second uses the Tango exoplanet transit tool to show how exoplanet orbits and sizes affect transits of their host stars.

Mapping E-modes with the South Pole Observatory - Amber Lennox

As instrument sensitivity increases, the search for primordial B-modes in the Cosmic Microwave Background (CMB) becomes ever more limited by our ability to model the effects of gravitational lensing by intermediate large scale structure. Gravitational lensing mixes bright E-mode signals into our faint B-mode target signal, necessitating accurate knowledge of the E-mode sky on all scales to successfully delense our observed sky maps. To do this effectively, it is necessary to combine multiple data sets from different telescopes that map the CMB at a variety of scales. We use simulated CMB data from the BICEP/Keck, South Pole Telescope and Planck collaborations to construct a joint E-mode auto spectra over a range of multipoles, which we then evaluate at different frequencies and compare to spectra derived from the individual experiments. We also model E-mode cross-spectra with temperature. This analysis also provides a method to evaluate consistency between experiments, as well as an interesting cosmological observable in its own right.

Searching for active galactic nuclei in post starburst galaxies - Emma Litzer

The trigger behind galaxy evolution from the gas-rich star forming phase to the gas-poor early type quiescent phase is unknown. Active galactic nuclei (AGN) are good candidates for

quenching galactic star formation and may hold the key to the cause of galaxy quiescence. AGN are known to inject excess energy into galactic material and generate intense winds, both of which provide negative feedback for star formation. To study the effect AGN have on quenching star formation, we look at a sample of post-starburst galaxies (PSBs) which are caught in the transition region between star forming and quiescence, making them excellent tools for observing evolutionary mechanisms. We use Prospector Alpha to fit the spectral energy distributions of 58 PSBs collected from Li et al (2019). Prospector alpha utilizes simulated spectral energy distributions and can be used to obtain Bayesian inferences of galaxy parameters. We use the CAPS allocation on the University of Illinois campus cluster to fit the spectral energy distributions of the PSB sample. Initial simulation runs show that 57 out of 58 PSBs show AGN flux below 2% of total galactic flux which indicate that a low number of PSBs show evidence of a dust obscured AGN.

X-Ray Luminous Supernovae: Ozone Damage and Threat Assessment - Connor O'Mahoney

The potentially hazardous effects of supernova (SN) explosions on terrestrial-like atmospheres have been widely studied in the last 20 years. Much of this research has focused primarily on the atmospheric damage from high-energy cosmic rays and gamma rays promptly emitted in the explosion. In this study, we turn the focus to persistent high-energy X-ray emission observed months and/or years after the initial outburst of certain SNe, thought to arise from interactions with a dense circumstellar medium. The influence that SN X-rays have on habitability has previously been overlooked, likely as a consequence of scant observational datasets in the X-ray band. Within the last few decades, however, more sensitive X-ray telescopes, notably Chandra, Swift-XRT, XMM-Newton, and NuStar, have enabled a more robust understanding of SN X-ray output. We use these modern datasets to conduct a risk analysis that sits within the context of the previous literature on SN terrestrial influence. We conclude that the X-ray energy outputs associated with Type IIn SNe and certain Fast Blue Optical Transients (FBOTs) have significantly larger “kill radii” than ordinary SNe. These events, while rare, pose a substantial threat to terrestrial-like radiation environments and may impose additional constraints on the Galactic habitable zone.

The future evolution of halos in Lambda CDM - Aaron Ouellette

The properties of clusters and dark matter halos are incredibly important to improve our understanding of cosmology. At the present epoch, clusters are not yet virialized due to continuing accretion and mergers. But, due to the accelerating expansion of the universe, in the future structure formation will effectively freeze out and become virialized. Here I present the results of cosmological N-body simulations that I ran past the present epoch, up to a = 100. I show that a spherical collapse model accurately describes the boundary of the halos in the final snapshot with a distinct boundary between particles falling into the halo and particles following the Hubble flow away from the halo. I additionally compare these results with the traditional friends-of-friends method of finding halos in simulations. This work will provide the foundation for future work to understand the structure and evolution of dark matter halos.

Spatially Resolved Properties of Post-starburst Galaxies - Bhavya Pardasani

We study and comapare the kinematics of post-starburst galaxies (PSBs) and early-type galaxies (ETGs) to help connect recent mergers undergone by galaxies to likely changes in their kinematics. We analyze spatially resolved properties like stellar velocity, stellar velocity dispersion, and angular momentum of 92 PSBs from MaNGA to place them in context with a sample of 260 ETGs from the ATLAS-3D project. We model the angular momentum at half light radius as a function of stellar mass and ellipticity at half-light radius to identify trends that are similar across both the samples. When we consider the percentage of galaxies that are slow-rotators, we find comparable number of slow-rotators in ETGs and PSBs. This is consistent with the PSB sample evolving into ETGs.

Modelling of CO rotation curves of data from the CARMA and ALMA EDGE millimetre-wave surveys - Ananay Sethi

Millimetre-wave measurements of star-formation properties of the z=0 universe have been conducted through various surveys using the CARMA and ALMA telescopes. This paper aims to model the datasets from the aforementioned surveys and extract rotation curves to derive the mass distribution in these galaxies. This paper uses the BBarolo modelling package and the Illinois Campus Cluster computing environment to model the rotation curves. The modelling is done using 20 arcsecond intervals to create rings radially outward from perceived galactic centers and will attempt to measure galaxies within a range of ~30 kpc. Using the rotation curves we will attempt to model the mass distribution and extrapolate the dark-to-luminous mass ratio to estimate the rate of accretion and evolutionary activity. This process will be conducted for 168 galaxies in the neighbouring universe.

Data driven M-dwarf flare model for ELAsTiCc - Ved Shah

Using single-band Kepler reference light curves, together with realistic physical parameters and Galactic extinction to build a model for M-dwarf flares in LSST passbands for ELAsTiCC.

Analyses of Filamentary Structures in the 30 Doradus Star-Forming Region - Eli Sofovich

The objective of this work was to further our understanding of the 12CO and 13CO filamentary-like molecular cloud structures within the 30 Doradus star-forming region in the Large Magellanic Cloud. Employing the fil_finder package, we generated an atlas of each filament complete with visualized information of the ridge and radial profiles. With this, we were then able to create a way to match specific Young Stellar Object candidates to the closest filaments from the CO mosaic as well as plot the properties of the overlapping filamentary and dendrogram structures found prior. Of note, the 12CO dendrogram leaves associated with filaments had high surface brightness, as expected, since the filaments are defined using the 12CO peak signal-to-noise ratio image. However, we find that the dendros on filaments tend to have lower virial parameters, corresponding to stronger gravitational boundedness. One can

say that the formation processes of these filamentary structures are related to gravity, which is supported by the 13CO emission tracing higher density gas and the association of 13CO and 12CO filaments.

Transient Detection and Classification with the South Pole Telescope - Chris Tandoi

The South Pole Telescope's third generation camera (SPT-3G) has detected over 250 transient events in its 1500 sqdeg field since 2020. A previously unexplored regime in time-domain astronomy, mm-wave transients are set to take off in the near future with the field's unifying project, CMB-S4, declaring them as one of the 4 primary science cases. I am currently working on simulating SPT observations of random transient events in our field with the hope of understanding (and improving!) our detection efficiency, and ultimately setting a framework for CMB-S4 when it sees first light at the end of the decade. The motivation for this project is to have a rigorous transient detection pipeline to aid in the classification of these events, and further analysis of my particular interest: stellar flares.

Selecting Dwarf AGNs in the Dark Energy Survey COSMOS Field with Optical Variability - Gabriela Torrini

Multi-wavelength searches for dwarf AGNs are fundamentally limited by their low accretion luminosities in the local universe. COSMOS-Webb, the largest JWST Cycle 1 program, will perform an ambitious NIR (MIR) deep imaging survey of half a million (32,000) galaxies. This data will supplement rich multi-wavelength imaging from over 10 other observatories. The wide area, depth, and multi-band coverage of COSMOS make it an excellent search field for dim dwarf AGNs. We use optical PSF and difference imaging from the Dark Energy Survey (DES) COSMOS deep field to construct light curves. Then, we perform star-galaxy separation and variability selection. However, these methods alone are insufficient to distinguish between dwarf and regular AGNs. In this poster presentation, I will discuss how to leverage ancillary data in the COSMOS field to investigate host galaxy properties and further select for dwarf AGN candidates.

FIRE Observations of Post-Starburst Galaxies - Akshat Tripathi

Galaxies evolve via a merger-driven scenario, in which, gas-rich spiral galaxies coalesce into gas-poor elliptical galaxies. The merger remnant experiences galaxy-wide shocks that result in an inflow of the molecular gas towards the center potential, resulting in a starburst event. This event fuels the central Active Galactic Nuclei (AGN), expelling the gas via stellar and AGN-driven shocks that quench the galaxy. Post-starburst galaxies are caught exactly in this transitioning phase. They show signatures of a recent starburst via strong Balmer absorption lines, produced by A-type stars that have a lifetime of ~ 1 Gyr. While these galaxies have experienced a recent starburst, they show very little signs of ongoing star-formation. Despite having low star-formation rates, a majority of post-starburst galaxies have significant reservoirs of cold molecular gas in them that should, theoretically, result in current star-forming activity. This work aims to look at a sample of post-starburst galaxies in the near-IR to determine the

low star-formation rates in post-starburst galaxies, despite the presence of star-formation fuel. We utilize various ro-vibrational transitions of the hydrogen molecule to determine the dominant excitation mechanism in post-starburst galaxies and in conjunction with near-IR, use optical data to to constrain dust geometry.

Variability of Active Galactic Nuclei Light Curves - Maya Vira

Active Galactic Nuclei (AGN) light curves have a gaussian distribution, but the elements of their light curves do not seem to correlate to the pattern of fluctuation. AGN light curves from the South Pole Telescope are bright and normally distributed. Their variabilities do not correlate to their flux, redshifts or luminosities. Through Kolmogorov-Smirnov tests and plotting with gaussian fitting routines, it can be proven that AGN light curves are in fact gaussian. The variability of AGN light curves are all around the same general value. However, when we plot the variabilities versus the flux, luminosity and redshifts, no pattern or trend is found. Therefore, AGN light curves vary randomly and uniquely.

Examining Exploding Transients in Spiral Arms - Holly Wingren

Previous studies have gained insight about the nature of supernova progenitors from statistically analyzing their positions within their host galaxy. If the dying star is relatively young, its properties will be tightly correlated to those in the surrounding stellar population. The purpose of this study is to compare the positions of different types of supernovae relative to the host galaxy's spiral arms and H II regions. By consolidating existing catalogs of supernovae and host galaxy pairs, we aim to validate the connection between Type II supernovae and star-forming regions of the host galaxy and discover new correlations for previously under-studied classes. The results of this study will shed light on the physics of explosive transients, which will be built upon using statistical samples from upcoming surveys.