2024 SPACE ASTRONOMY SUMMER PROGRAM SYMPOSIUM

Thursday, August 1, 2024

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

LITTLE DUMBBELL NEBULA

The 2024 Space Astronomy Summer Program (SASP) is a long-running program at the Space Telescope Science Institute. Now in its 32nd year, it is widely recognized as a place for interns to learn, grow, connect with others in varied fields within (and adjacent to) Space Astronomy, and be supported in their efforts throughout their internship.

The SASP Symposium provides a platform for the interns to present their work to peers, mentors, STScI staff—as well as friends and family members.
The goals of SASP are:

- To expose interns to leading research in astrophysics and related fields, and the workings of a space-based observatory
- To provide interns with opportunities for growth, achievement, and personal development
- To place interns in a cohort of friends and colleagues

In this SASP Symposium Program booklet, you will see the projects that 15 SASP interns, as well as an additional six non-SASP interns, worked on during their internships. We congratulate them on their efforts and share them here with you.

— Carolyn Slivinski
2024 SASP Program Chair, on behalf of the SASP Executive Committee

PILLARS OF CREATION (VISUALIZATION MOSAIC)

2024 Space Astronomy Summer Program

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Cloud Chasers: Towards a Data-Driven Approach to Exoplanet Cloud Predictions with JWST

Ceiligh Cacho-Negrete, *Wellesley College*
Mentors: Néstor Espinoza, *Mission Scientist for Exoplanet Science*
Amelie Gressier, *STScI Postdoc*

What defines the cloudiness of a given exoplanet? While attempts have been made to make predictions about cloud trends using HST data, the relatively narrow wavelength range used to make them has made those predictions either unsuccessful or have poor predictive power. The past few years, however, have been revolutionized by the quality and wavelength coverage of JWST exoplanet spectra—which provides in turn data that can in principle be used on their own (i.e., independent of models) to perform such trend searches and predictions. Whether these observations as a population live up to that promise, however, is still unclear. Here we present the first results at "mining" existing time-series data for transiting exoplanets to explore exoplanet spectra as a population, in search for possible trends using the technique of transmission spectroscopy.

JWST Fine Guidance Sensor Visits Summary Analysis Automation

Olivia Canevari, *University of Maryland College Park*
Mentor: Amanda Marrione, *Senior Flight Systems Engineer*

This project focuses on automating the analysis of FGS (Fine Guidance Sensor) guiding statistics typically recorded in Excel spreadsheets. The aim is to develop a user-friendly Python script capable of processing these statistics directly from an input Excel file. The script generates two main histograms: one displaying the distribution of pass, fail, and retry outcomes across all recorded data points, and another categorizing failures specifically by their occurrence in ID (Identification), ACQ (Acquisition), or TFG (Track & Fine Guide) phases.

The automation process involves parsing the Excel data to extract relevant guiding statistics, including the number of successful passes, retries, and failed attempts. These statistics are then visualized using Python's Matplotlib library to create intuitive histograms. The first histogram provides an overview of the overall performance trends, illustrating the frequency and distribution of each outcome category. Meanwhile, the second histogram offers a detailed breakdown of failure types, highlighting whether failures occurred during ID, ACQ, or TFG stages.

By encapsulating this functionality into a single, easy-to-use script, users can streamline the analysis of FGS guiding statistics without the need for manual data processing or complex spreadsheet operations. This approach not only enhances efficiency but also facilitates clearer insights into the performance and reliability of FGS guiding operations, crucial for ongoing monitoring and decision-making in astronomical observation and guidance systems.

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Collaborate with Team Indigo on Jdaviz

Katherine Carver, *University of Maryland Baltimore County*
Mentor: Jesse Averbukh, *Software Engineer ;*
Co-mentor: Camilla Pacifici, *Staff Scientist*

The Indigo development team has been developing JWST analysis tools since before launch. These tools are constantly evolving to adapt to the scientific demands of JWST observations and Katherine developed additional features to a tool as part of an agile software development team. The specific tool worked on this summer was the catalog plugin, which allows astronomers to view sources of interest from various catalogs plotted over a view of their data. The tool also allows for multiselect of sources for the purposes of zooming and other capabilities to be determined in the future.

Rectifying Poor Flux Calibration of COS Data due to Bad Time Intervals

Andrews Damoah, *University of Maryland College Park*
Mentor: Sten Hasselquist, *Senior Staff Scientist*

A small but undetermined fraction of COS observations are affected by unexpected drops in count rate due to a variety of reasons, including situations where the target has drifted out of the aperture. These observations thus end up with poor flux calibration. We will identify affected exposures in the COS archive and determine a list of bad time intervals to update the BADTTAB reference file, correcting these exposures in the archive. We will also investigate the causes of some of these bad time intervals to determine if some of the objects are intrinsically variable.

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The Cloud Computing Advantage

Vivek Dubey, *Vel Tech Rangarajan Dr. Sagunthala R and D Institute of Science and Technology*

Mentor: David Uselmann, *Senior Technologist – Cloud Services*

With rapid parallel scaling analysis of petabytes of data for training AI models and discovering exoplanets, cloud computing vastly accelerates scientific productivity. Using one of STScI's cloud environments, the intern will provide value by deploying a small automated project in the AWS cloud that computes results on demand and in parallel. The intern will experience a firsthand appreciation for the cloud's paradigm shift in computing by creating a functional service. They will experience how cloud computing can be a science accelerator, and be able to take their experience to market their career

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Cosmic Beacon: leveraging information from the intra-cluster light to study the dark matter mass distribution in clusters

Daniel Fistos, *University of North Carolina Asheville*
Mentor: Amanda Pagul, *Postdoctoral Fellow*
Co-mentor: Dan Coe, *ESA-AURA Astronomer*

The gas responsible for the emission of the so-called intracluster light (ICL) is bound to the extreme gravitational fields happening in clusters. Several studies show indications that the ICL is correlated with the dark-matter field (Montes-Trujillo et al. 2019, ++). Under that premise, the ICL can potentially inform the creation of mass maps, if the correlations between mass and ICL are quantified and understood.

Using the method described in Pagul et al., we generate ICL maps to develop metrics to quantify the correlation between DM and the ICL, and to inform us about physics on small- and large-scales, how light traces matter on small scales, and how that can inform our understanding of the light to mass ratio in larger scales. We present our findings which show a correlation between the ICL models and the dark matter lensing models themselves.

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Insight into the Cloud Properties of Exoplanets and Brown Dwarfs from JWST Spectra

Intern: Ja'Heim Goodwin, *Alabama A&M*
Mentor: Joshua Lothringer, *Assistant Astronomer*
Co-mentor: Jeff Valenti, *JWST Mission Scientist*

The IR spectroscopic capabilities of JWST open a new window into the atmospheres of sub-stellar objects (i.e., planets and brown dwarfs). We will compare cloud optical properties to recent JWST/NIRSpec and MIRI observations of brown dwarfs to understand in more detail the properties of clouds, which dominate the spectrum of both planets and brown dwarfs. These properties include the particle composition, size, location, and even crystal structure. We will compare these results to recent analogous observations of exoplanets to understand how cloud properties vary across the sub-stellar regime.

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A Comprehensive SED Library of Type Ia Supernovae for the STIS ETC

Xander Jenkin, *Princeton University*
Mentor: Matthew Siebert, *Postdoctoral Fellow*
Co-mentor Joleen Carlberg, *STIS Branch Manager*

The Space Telescope Imaging Spectrograph (STIS) on the Hubble Space Telescope is an incredibly versatile instrument for the study of transient astrophysical phenomena (e.g., supernovae, kilonovae, tidal disruption events, etc.). STIS is the only instrument that is capable of obtaining high-quality ultraviolet (UV) spectroscopy of these targets. Observations of these targets are often time-sensitive and their UV properties are often uncertain. STIS contact scientists are required to quickly conduct reviews for the purpose of ensuring the safety of STIS's sensitive MAMA detectors. Currently, the STIS exposure time calculator (ETC) does not include any template spectra of transient phenomena. We have generated a library of multi-wavelength, reddening-free template spectra of type Ia supernovae based on observations in the literature. This library spans a wide variety of potential observing scenarios and will aid the STIS team when conducting independent reviews of STIS programs. Select templates from this library may then be incorporated into the STIS ETC.

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Characterizing the NIRCam Coronagraphs at the Smallest Angles to Image New Exoplanets

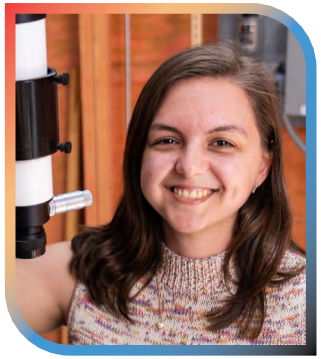
Rohan Kane, *University of Maryland College Park*
Mentor: Julien Girard, *Scientist*

JWST/NIRCam harbors 5 occulting masks to block the light of a bright host and image faint astrophysical signals around it. Coronagraphic imaging is often used to detect self-luminous giant exoplanets orbiting bright, nearby stars. While the mode works well and already delivers striking science results, we think JWST can detect new planets and we would like to push its limits in contrast, especially at short angular separation. We have acquired a wealth of calibration data to compare the different masks. The project will revolve around generating calibrated contrast curves, evaluating means to push performance and efficiency, making NIRCam Coronagraphy even more transformative! This will be accomplished through the use of archival data to build PSF reference libraries for the optimal removal of the residual stellar glare. The intern will also learn how to perform state of the art photometry and astrometry of companions and will be invited to attend the high-contrast “EPSIG” research group meetings with junior and senior members.

Spectroscopic Characterization of YSES-1 b and c

Piper Lentz, *Amherst College*
Mentors: Kielan Hoch, *Giacconi Fellow*
Laurent Pueyo, *Associate Astronomer*

YSES-1 is a multiplanet system, with two young, directly imaged planets orbiting a solar analog, the lowest mass star to host multiple directly imaged planets. In this report, we characterize the spectral types of YSES-1 b and c using JWST spectral data and the only available spectral dataset passed three microns for substellar objects (AKARI). This characterization will update previous predictions by ground-based observations. Assigning spectral types to these planets facilitates understanding spectral features, and will therefore inform future chemical abundance measurements and atmospheric characterization. Effective temperature and surface gravity, characteristics spectral types are sensitive to, can be better predicted as well, allowing us to uncover answers to how this system evolved and formed. To characterize the spectral types of YSES-1 b and c, we conducted chi-square tests comparing the spectra of each planet with 16 brown dwarf spectra from the AKARI sample, each of which has a known spectral type. We found that for both YSES-1 b and c, the best matching spectral type was L5. However, the chi-square values were broad, indicating that L1-L6 are close matches for YSES-1 b, and L4.5-L6 are close matches for YSES-1 c. This is inconsistent with the predictions of L0 and L7.5, respectively, of ground-based observations. This is significant because space-based wavelength range is more impacted by clouds and circumplanetary material due to the youth of these objects and the fact they may have formed in a disk rather than as isolated brown dwarfs. These features and impacts are not seen from the ground, which explains the discrepancy.



STIS ETC Validation of Lesser Used STIS Modes

Shannon Markward, *Towson University alum*
Mentor: Daniel Stapleton, *Science Support Analyst I*

The Hubble Space Telescope (HST) Exposure Time Calculators (ETCs) are online tools designed for astronomers to accurately plan their observations. Annual calibration programs for the Space Telescope Imaging Spectrograph (STIS) provide corrections that keep the ETC outputs accurate for the most commonly used observing modes of the instrument, while assuming those corrections can also be applied to the lesser used STIS observing modes. In this talk, I will be discussing an initial investigation into the validity of those assumptions by comparing time-dependent sensitivity (TDS) data to the outputs of the ETC. I will end by discussing our goal of developing a method to compare the ETC outputs with resulting science exposures and applying that method to lesser used STIS observing modes.

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Evaluating Large Language Models in Research Astronomy

Kiera McCormick, *Loyola University Maryland*
Mentor: John Wu, *Assistant Astronomer*

Large language models (LLMs) are being used not only for common-knowledge information retrieval, but also for specialized disciplines such as cutting-edge astronomical research. However, we lack robust, realistic, and user-oriented evaluations of LLM capabilities. Furthermore, there is limited research on how researchers actually interact with LLMs, and how the field of astronomy benefits from them. The primary aim of this project is to develop and quantify evaluation standards by analyzing user-LLM interactions from STScI researchers. In other words, this project explores the first step toward a lofty goal: how can AI transform science for the better, by first evaluating what it means to be “better”.

This SASP project will be coordinated in partnership with another Johns Hopkins University (JHU) summer program comprising expert computer scientists, linguists, and astronomers.

Modeling Debris Disks Around Polluted White Dwarfs

Ashley Messier, *Smith College*
Mentor: John Debes, *ESA/AURA Astronomer*

Observing white dwarf circumstellar environments provide insight to the extent of exo-planetary systems and the fate of systems such as our own. White dwarfs with metallic absorption lines, dubbed “polluted white dwarfs”, are ideal candidates in the search for post-main sequence planetary systems because the presence of metals indicates active accretion of asteroid-like material that has been perturbed by a planet in the system and fallen onto the star. Many polluted white dwarfs exhibit infrared excesses from debris disks or planet thermal emission, and by modeling the excess emission, we may diagnose the likely source and learn more about evolved exoplanetary systems. JWST mid-infrared observations of 3 polluted white dwarfs display significant infrared excess at 15 and 21 microns, and we explore the possibility that the excess is due to thermal emission from a debris disk. By simulating debris disks with motivated physical properties such as grain size distribution, disk composition, and inner/outer radii, we compare model disk spectra to the observed infrared excesses to determine the likelihood the excess is due to a debris disk rather than a cool planet. For one target imaged in the MIRI Excess Around Degenerates (MEAD) survey, we observe an infrared excess but not metal accretion, indicating the excess is likely due to a planet rather than a debris disk. As a follow-up project, we aim to systematically model debris disks for several well-observed dusty white dwarfs to get a sense of what trends may exist in the population of white dwarf debris disks and to test how well aligned current theory is to observations.

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Developing Outreach Material for the Nancy Grace Roman Telescope

Patricia Molinari, *University of Massachusetts Amherst*
Mentor: Ann Jenkins, *Principal Science Writer*
Co-mentor: Ray Villard, *Hubble Space Telescope News Chief*

Embedded in STScI's Office of Public Outreach, the intern will create engaging outreach text for the Nancy Grace Roman Space Telescope, a panoramic survey telescope scheduled to launch by 2027. Working alongside professional science writers and other outreach experts, the intern will develop content for:

- A Roman Press Release on the RINGS (Roman Infrared Nearby Galaxy Survey) Program. This is a large, wide-field science program to develop software for the community to simulate and analyze Roman surveys of nearby galaxies. The SASP intern will: conduct background research; interview the Principal Investigator and science team; draft the release text and ancillary material; iterate with the RINGS team and reviewers at STScI and NASA; help develop the accompanying graphic; and prepare the release and associated material for publication. This release will be published in mid-to-late August.
- Social Media Posts to promote online Roman articles. Using exciting and colloquial language, the intern will explain the importance of the articles' topics in posts that will appear on popular social media outlets.
- Alt Text for Graphics that appear in online Roman articles. This descriptive and engaging text is critical for communicating the content of the graphics to the blind and visually impaired.

Additionally, the SASP intern will shadow the Office of Public Outreach's professional science writers and attend regular meetings of the science writers and News staff.

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Predicting Black Hole Masses Using Machine Learning

Seti Norris, *Johns Hopkins University*
Mentor: Suvi Gezari, *Associate Astronomer with Tenure; Chair of Sr. Sci. Staff*
Co-mentor: Mitchell Karmen, *JHU grad student*

A tidal force is the result of a gravitational interaction between two objects, in which the more massive object pulls the nearest side of the other object towards its center of gravity and pushes the farther side away. When a star drifts close enough to a black hole, it is ripped apart by these gravitational forces in what is called a Tidal Disruption Event (TDE). Based on the type of star affected, TDEs can be used to estimate black hole masses and perhaps find the elusive intermediate mass black holes. It has long been theorized that the lightcurve of a TDE can be used to predict the mass of the black hole involved. In this project, we seek to use machine learning to classify tidal disruption events and find their black hole masses. Taking data from various surveys, such as ztf, we make lightcurves and spectral energy densities (SEDs) for 92 TDEs. We then will use gaussian processes, and a simple mean model to fit the SEDs to a blackbody spectrum, to interpolate the lightcurves in time and wavelength. Once our lightcurves are processed, we will apply autoencoder machine learning techniques in order to organize our TDEs into a low dimensional latent space. We plan to search this latent space for trends in TDE properties, and optimize this space for black hole mass prediction.

Machine Learning for Determining Star Cluster Ages

Sophia Rivera, *Johns Hopkins University*
Mentors: Janice Lee, *Project Scientist*
John Wu, *Assistant Astronomer*

This project, currently in progress, is a collaborative effort to direct the power of machine learning towards advancing our understanding of star cluster evolution. The primary objective is to develop a robust convolutional neural network (CNN) model capable of accurately determining the ages of star clusters. The model is being trained with image cutouts of individual clusters within galaxy NGC 628 – a spiral galaxy with ample HST and JWST imaging. The HST and JWST bands offer a comprehensive spectral range, perfect for training and enhancing the model's age estimation accuracy.

A convolutional neural network processes image data to recognize and learn intricate patterns; when applied to our imaging, it will detect subtle variations in star clusters and find indications of age. The completion of this project aims to overcome some of the limitations of traditional photometric and spectroscopic methods of age determination, and hopefully demonstrate the efficacy of machine learning methods in stellar research.

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Red Giants' Stellar Companions in SDSS-V

Jacqueline Sanchez, *Houston Community College*
Mentor: Joleen Carlberg, *STIS Branch Manager*
Co-mentor: Rachael Beaton, *Associate Astronomer; Deputy Branch Manager, Roman Telescope Branch*

The binary working group within the Sloan Digital Sky Survey (SDSS-V) is obtaining multi-epoch infrared spectra of stars across the HR diagram, with an emphasis on M dwarfs, subgiants, and red giant stars. Some of these stars have legacy observations from SDSS-III and SDSS-IV and thus a large temporal baseline of radial velocities (RVs), while others will be observed for the first time within SDSS-V. These data will allow rich explorations on the stellar companion fractions in our galaxy as well as studies of the intrinsic RV variability of the most evolved stars. With the SDSS-V survey underway, early scientific studies co-exist with efforts to vet and validate the primary spectroscopic measurements of RVs, abundances, temperature, gravity, etc. Here, we present a first look at the companions of a sample of ~10 well-characterized red giant stars.

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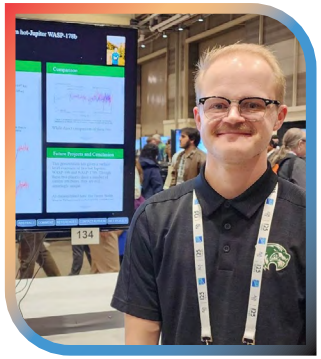
A Semi-Empirical Approach for Photometric Zeropoints Using Stars

Maya Seagraves, *California Polytechnic State University*
Mentor: Rachael Beaton, *Associate Astronomer; Deputy Branch Manager, Roman Telescope Branch*
Co-mentor: Tyler Desjardins, *Deputy Branch Manager, Roman Telescope Branch*

Understanding the detailed properties of stars in the infrared is of critical importance with new missions focusing on the infrared (JWST, Roman). The ground-based wide-field infrared instrument, FourStar, on the Magellan telescope contains a number of medium band filters that are optimized for photometric redshifts, but also provide nearly continuous spectral coverage for stars. These filters, however, lack absolute calibration. In this project, we will adapt a technique used for galaxies to be used for stars. We will use multi-band photometry to fit a likely SED model to each star and then generate synthetic photometry from the SED model to produce the magnitude of the star in a given filter. Statistically, we can then determine the zero point in each filter in each image. This will be used to calibrate a large survey aiming to better understand near-infrared properties of stars for application to the extragalactic distance scale (with JWST and Roman).



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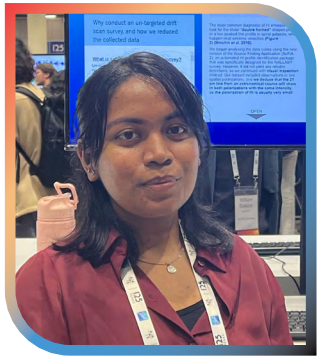
Atmospheric Characterization of a T-Y Brown Dwarf, Analog to Cool Directly-Imaged Exoplanets

Brian Seamons, *Utah Valley University*
Mentor: Elena Manjavacas, *ESA/AURA Astronomer*
Co-mentor: Natalia Oliveros-Gomez, *Johns Hopkins University grad student; Davidsen Fellow*

Young brown dwarfs are analogs to giant exoplanets, as they share effective temperatures, near-infrared colors and surface gravities. Thus, the detailed characterization of young brown dwarfs through spectroscopy might shed light on the study of giant exoplanets, that we are currently unable to observe with the sufficient signal-to-noise to allow a precise characterization of their atmospheres. We obtained a high signal-to-noise spectrum of the 2.3 MJup Planetary-Mass brown dwarf, WISEPC J225540.74-311841.8 (T8.0) using the J, H and K-band of MOSFIRE at Keck I. Here we present the results of the comparison of the spectra of WISEPC J225540.74-311841.8 to different grids atmospheric models for brown dwarfs, and to other template late-T dwarfs.



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Unveiling the Young Stellar Population in our Low Metallicity Neighbor with JWST

Mahpara Tasnim, *Montana State University*
Elizabeth Tarantino, *STScI Postdoc*

The most direct way of studying the ongoing star formation in galaxies is to examine the population of Young Stellar Objects (YSOs), which are protostars beginning their earliest stage of evolution. This project will utilize the exquisite resolution of JWST at infrared wavelengths to detect, characterize, and measure the YSO population in the low metallicity, dwarf galaxy Sextans A. We use photometric catalogs from NIRCam and MIRI to construct color magnitude diagrams and identify potential YSO candidates. We visually inspect the YSO candidates to remove interloping galaxies and determine the JWST color-color space that yields high-quality YSO candidates. The YSO candidates are compared to state-of-the-art models from Richardson et al. 2024 to determine their properties. We also combine the YSO population in Sextans A with tracers of the ISM to identify regions of enhanced star formation.

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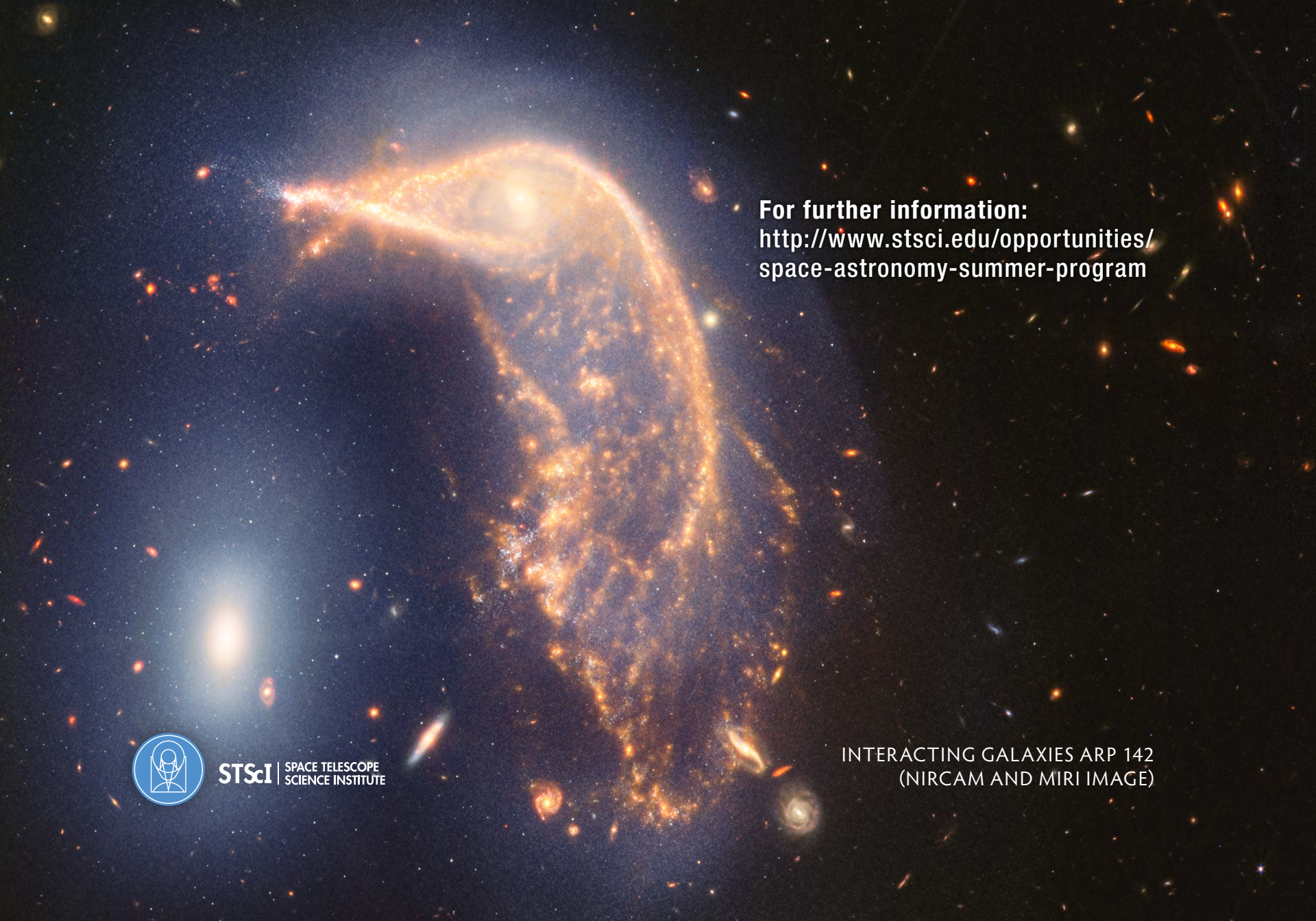
Plan Longitudinal Analysis Tool

Britney Whittington, *Towson University alum*
Mentor: Mark Giuliano, *APSB Branch Manager*
Co-mentor: Diego Mundo, *Software Engineer II*

Operations staff at STScI use the SPIKE software system to create long range plans for scheduling HST, JWST, and Roman observations. While tools exist to examine individual long-range plans, there are limited long term metrics, and no capabilities to visualize how plans evolve over time. The Plan Longitudinal Analysis Tool (PLAT) supports creating textual and visual reports for investigating the stability of long-range plans over the course of a mission. The project is integrated with the operational SPIKE system and will be demonstrated using cycle 0-3 JWST long-range plans.



For further information:
http://www.stsci.edu/opportunities/space-astronomy-summer-program

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INTERACTING GALAXIES ARP 142
(NIRCAM AND MIRI IMAGE)