2022 SPACE ASTRONOMY SUMMER PROGRAM SYMPOSIUM

THURSDAY, AUGUST 4 · 2022

SPACE TELESCOPE SCIENCE INSTITUTE
BALTIMORE · MARYLAND

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SOUTHERN RING NEBULA

The Space Astronomy Summer Program (SASP) continued its virtual-only program for students and mentors alike in 2022. While working in a remote environment continues to be challenging, the interns met these challenges and succeeded.

During this 30th year of STScI’s summer intern program, we continue to work towards these goals:

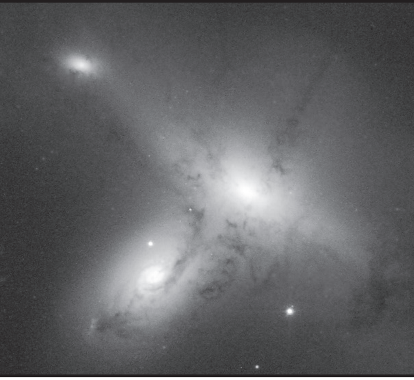
- To expose undergraduates to leading research in astrophysics, and the workings of a space-based observatory
- To provide participants with opportunities for growth, achievement, and personal development
- To place students in a cohort of friends and colleagues

In this Program Booklet, you’ll find twelve interns who were part of SASP, and two additional students who interned for STScI outside of SASP. We are happy to be able to share the accomplishments of all of these interns with you!

— **Carolyn Slivinski**
2022 SASP Program Chair, on behalf of the SASP Executive Committee

SUPERNOVA REMNANT 1E 0102.2-7219

2022 SPACE ASTRONOMY SUMMER PROGRAM



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SASP

Separating the Cosmic from the Instrumental in Roman Data Using Machine Learning Techniques

Phani Velicheti *University of Arizona*

Mentor – *Dr. John Wu (Assistant Astronomer)*

Co-Mentor – *Dr. Andreea Petric (Associate Scientist)*

The Roman Space Telescope will provide high-resolution imaging similar to that of Hubble Space Telescope, but Roman will also deliver a 100 times larger field of view. The success of this mission depends on a thorough understanding of the detector and observational systematics; therefore it will be critical to carefully vet the imaging data. The Roman Wide Field Instrument (WFI) will produce over 1 TB of data per day, rendering manual inspection of the data infeasible. Using computer vision and machine learning (ML) algorithms, we characterize Roman WFI dark frame images taken in NASA's Detector Characterization Laboratory. We present a preliminary comparison between Fourier transforms, wavelet filtering, and neural networks, which provide different ways to quantify the impact of correlated structures and imaging artifacts.

SASP

Software Contributions to JWST Data Analysis Tools

Sabrina Volfman *University of Maryland Baltimore County*
Mentor – *Jesse Averbukh (Software Engineer II)*
Co-Mentor – *Richard O'Steen (Software Engineer II)*

We describe our work simulating science data from the Roman Space Telescope Wide Field Instrument. These data will be used as part of the verification and scientific validation of the Roman science data pipeline. We adapt pre-existing Fortran code for simulating images by adding a Python wrapper, converting FITS format output files to the ASDF Roman data format, and implementing catalog-generation tools for simulating astronomical scenes. In this presentation, we describe in detail the process used for simulating Roman data, the ASDF format used for Roman, and the scientific considerations used in generating the input catalogs.

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Automated Functional-Regression Testing of WASABI Software

Federico Sandi *University of Maryland, College Park*
Mentor – *Jeff Bucklew (Software Engineer II)*
Co-Mentor – *Maria Bertch (Consulting Software Engineer), Joel Richon (Consulting Software Engineer)*

Regression testing is the practice of testing existing software systems to ensure recent changes haven't broken existing functionality or introduced new bugs (a failure is considered a regression). Thus, regression testing is an essential quality assurance (QA) process by which teams ensure the stability and functionality of a system. Functional testing is the practice of testing systems, or their components, against documented formal specifications. Until recently, WASABI test engineers performed manual functional-regression tests, during which they performed manual interactions with a software system to verify functionality, per component, either according to an existing specification or while simultaneously developing a specification. This is prohibitively time-consuming. Thankfully, automating this process is possible. WASABI now utilizes the Geb functional-testing framework, based on the popular Selenium framework and adapted to the Groovy programming language, to develop automated functional-regression tests. Benefits include both freeing up test engineers to work on more QA specifications, which in turn drive more automated tests, and opening up the development of these tests to developers, increasing the number of people and breadth of expertise working to ensure system stability.

Assessing Performance of NIRSpec in Exoplanet Imaging

Alexis Li *Johns Hopkins University*

Mentor – *Christine Chen (STScI Associate Astronomer)*

NIRSpec (Near Infrared Spectrograph) is one of the four instruments on JWST and is an important tool in detecting and studying exoplanets. One of the techniques of exoplanet detection is high-contrast imaging, which is often used for faint companions near bright sources' point spread function (PSF) subtraction during the data processing stage. PSF subtraction is removing a reference source from the target at each wavelength to reduce the impact of light from the bright source, revealing the faint companion. My project focuses on using the NIRSpec integral field unit's (IFU's) commissioning data, processing the data through JWST pipelines, and then applying custom PSF subtraction tools to locate the faint companion in the target system. To assess the performance of the NIRSpec IFU in exoplanet imaging, we plot the contrast curve of contrast performance as a function of angular separation. And to further visualize the performance, we compare the NIRSpec IFU's performance to already discovered exoplanetary systems.

SASP

Exploring Atmospheric Escape Models for Hot Exoplanets

Daniel Ramos-Padilla *University of Texas at El Paso*
Mentor – *Dr. Leonardo dos Santos (STScI Fellow)*

Atmospheric escape is considered to be one of the main channels for evolution in sub-Jovian planets, particularly in their early lives. While there are several hypotheses proposed to explain escape in exoplanets, testing them with atmospheric observations remains a challenge. In this project, we aim to explore the impact of the mass loss rate and outflow temperature in the observable signatures of atmospheric escape in hot exoplanets. The results will inform future efforts in interpreting observations obtained from the ground and with JWST.

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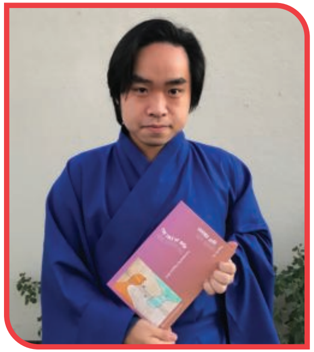
Comparing Chemistry of Small Molecules in Planet Forming Disks

Carlos Ortiz-Quintana *University of Puerto Rico Mayagüez*
Mentor – *Dr. Nicole Arulanantham (Giacconi Fellow)*

New planets form in disks of gas and dust surrounding young stellar objects (YSOs). The composition of the gas can be investigated by observing molecules in the disks. When the molecules “rotate,” they produce light at sub-millimeter wavelengths. This light is then observed with instruments like the Very Large Array (VLA) and the Atacama Large Millimeter/submillimeter Array (ALMA). For this project, we will focus on light from small molecules in a sample of planet-forming disks with data available in the ALMA archive. Each of our targets has also been observed with the Hubble Space Telescope, which revealed the ultraviolet radiation from the YSOs. These high-energy photons regulate the chemistry of molecules in the disks, playing an important role in setting the abundances and spatial distributions of many carbon, oxygen, nitrogen, hydrogen, and sulfur-bearing species. Using data from the two instruments, we will explore the distributions of molecular gas in systems that receive different levels of ultraviolet light. This work will show how the compositions of the protoplanetary disks might change over time as the YSOs evolve.

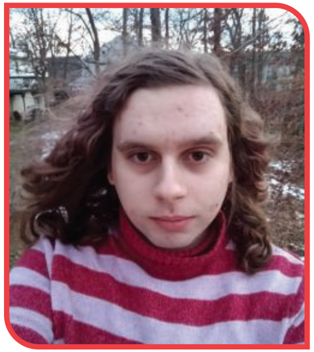


SASP

Unlocking the Histories of Galaxies by Simulating Stellar Halos

Binh Nguyen *University of Arizona*
Mentor – *Anna Wright (Assistant Research Scientist at JHU)*
Co-Mentor – *Ayan Acharyya (postdoctoral researcher at JHU), Cassi Lochhaas (postdoctoral researcher at STScI)*

The Milky Way and many other galaxies in our cosmic neighborhood are surrounded by faint halos of stars that extend far beyond the main disk. These include some of the oldest stars ever observed, and are all that remain of the many low-mass (or “dwarf”) galaxies that were torn apart by tidal forces during collisions with larger galaxies. These stellar halos therefore encode a detailed “fossil record” of interactions between galaxies that we can't otherwise access. The FOGGIE group uses high-resolution simulations of galaxies and their environments to understand the physical processes that drive galactic evolution and to explain and predict observations from the Hubble Space Telescope, the James Webb Space Telescope, and the upcoming Roman Space Telescope. In this project, we examine the properties of dwarf galaxy satellites of a simulated Milky Way-like galaxy and compare the properties of those that remain gravitationally bound to those that are tidally disrupted, and have therefore contributed their stars to the stellar halo of their host. We also characterize the rate at which each disrupted satellite loses its stars along its orbit, in order to better understand how the properties of satellites influence the stellar halos that they create.



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Visualizing the Spiral Structure of the Milky Way

Caroline Nunn *University of Maryland, College Park*
Mentor – *Dr. Frances Cashman (Post-doctoral fellow, STScI)*
Co-Mentor – *Dr. Andrew Fox (ESA/AURA astronomer, STScI)*
Co-Mentor – *Dr. Trisha Ashley (Post-doctoral fellow, STScI)*
Co-Mentor – *Dr. Dhanesh Krishnarao (Post-doctoral fellow, JHU)*

We combined UV data of Galactic Center stars from the Hubble Space Telescope and other missions (FUSE, IUE) with current position models for the Milky Way's spiral arms in order to create descriptive visualizations of the spiral structure in the disk of the Milky Way. Using Python-based tools on a new database of UV absorption line measurements from 23 sight lines toward bright stars in the Galactic Center, we have explored different options to create innovative visualizations of the spiral structure in the disk of the Milky Way. These bright stars function as background light sources, and enable us to pierce the foreground dusty interstellar medium to reveal gas associated with the spiral arms. Our Galactic Center sight-line sample probes the Sagittarius, Scutum-Centaurus, Norma, and "Near 3 kpc" spiral arms. We have identified the spiral arm components within our database and have designed a variety of visualizations including 2D top-down maps and 3D position-position-velocity maps. A major future goal for these visualizations is to graphically characterize the spiral arm structure in terms of chemical composition, dust, molecular gas fraction, and ionization levels.

SASP

Unveiling the Nature of Diffuse Interstellar Envelopes Around Dense Star-forming Clouds

Elijah Mullens *University of Florida*
Mentor – *Catherine Zucker (Hubble Fellow)*
Co-Mentor – *Claire Murray (Assistant Astronomer)*

Understanding the structure of interstellar clouds is essential to painting a large-scale picture of how dense molecular medium collapses to form young stars and ultimately protoplanetary disks, and how galactic feedback regulates star formation and forms filament-like structures seen in observational data. However, analyzing the structure of clouds has traditionally been difficult because most measurements are restricted to two-dimensional “plane-of-the-sky” maps, which makes it challenging to build a physical picture of the cloud. Thanks to new “3D dust maps” (Leike et al. 2020), we now have the opportunity to analyze cloud structures in 3D. Recent work leveraging these 3D dust maps (Zucker et al. 2021) has suggested that clouds have two prominent components: a thin, dense, inner layer and a broad, sparse, outer layer. However, we do not know how the 3D dust structure maps on to the physical conditions of the gas. We leverage recent numerical simulations of highly resolved interstellar clouds in a Milky Way-like Galaxy to test how the structure of clouds is affected by the physical conditions occurring in the simulated galaxy. Extracting clouds from the numerical simulations, we measured the clouds’ radial density profiles in multiple cloud-structure tracers. In contrast to observations, we find that simulated clouds were heavily influenced by supernova feedback, creating a shock structure in the temperature and drastically reducing the extent of their atomic envelopes.

SASP

Ionized Gas Morphology in Galaxies Hosting Supermassive Black Holes

Lacey Allee-Press *University of Maryland, College Park*
Mentor – *Dr. Darshan Kakkad (Postdoctoral Researcher, STScI)*
Co-Mentor – *Dr. Travis Fischer (ESA/AURA Astronomer, STScI)*

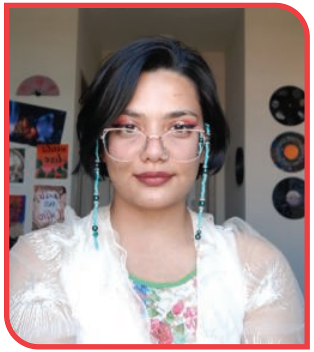
Most galaxies host a supermassive black hole at their center. Although these black holes are 1,000 times smaller than the host galaxy itself, powerful radiation in the form of radio jets from these black holes can affect how the host galaxy evolves. One way that we can track the extent of the black hole's influence on the host galaxy is to observe ionized gas via emission from doubly ionized oxygen in the optical wavelengths. Using data from state-of-the-art MUSE instrument on board the Very Large Telescope (VLT) in the Atacama Desert in Chile, we will construct images of ionized gas emission in 10 nearby galaxies hosting active black holes. These black holes are known to host radio jets that can potentially affect the morphology and kinematics of gas in the interstellar medium. MUSE is an integral-field spectrograph, which simultaneously provides both spatial as well as spectral information of these galaxies, and is one of the most versatile astronomical instruments to date. The ionized-gas images that we will derive from the MUSE data will then be compared with the existing radio images of these galaxies to test the hypothesis that the radio jets affect the morphology of the ionized gas. We will also investigate if the velocity of the ionized gas is affected at the location of the radio jets by analyzing the shape of the doubly ionized oxygen emission line.

SASP

JWST's Deep Space Network Contact Calendar

Sharyn Gerber *Binghamton University*
Mentor – *Amanda Arvai (SEITO Deputy Division Head)*

The Flight Operations Team (FOT) is responsible for sending commands and monitoring telemetry for NASA's James Webb Space Telescope (JWST). After launching in December 2021, the process of commissioning the observatory followed. This was a six-month period during which we configured the spacecraft, telescope, and instruments. In July 2022, we transitioned into a Normal Operations phase, during which the Flight Operations Team is primarily responsible for its health and safety. In Normal Operations, JWST communicates with the ground using the Deep Space Network (DSN). The intern on this project created a python code to document and organize details of DSN station contact with the telescope in an accessible calendar format. This will allow flight operations personnel to view the schedule on their personal phones or in their Outlook calendars, which is particularly helpful since contacts vary significantly day-by-day.



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Optical and HST/STIS UV Spectroscopy of the Interacting Type Ibn SN 2020nxt

Anika Goel *University of Kansas*

Mentor – *Ori Fox (JWST MIRI Instrument Scientist)*

A growing number of supernovae (SNe) are showing evidence of significant interaction with a dense, pre-existing, circumstellar medium (CSM). Furthermore, this dense CSM tends to create extreme scenarios, defined by high luminosities and/or rapid evolutionary timescales. The origin of this CSM remains mysterious, especially given the fact that it is found in so many different types of supernova types. This very CSM, however, can serve as a “smoking gun,” providing a direct probe of the pre-SN star’s evolution and mass loss prior to explosion. In this talk, I will present a series of spectra for SN 2020nxt, a Type Ibn with ground-based optical and infrared spectra and HST/STIS UV spectra. I will present a Python-based code using Jdaviz to measure the emission line strengths and equivalent widths as a function of time. I will discuss the implications of the results, compare them to radiative transfer models, and highlight future work.

SASP

Constructing Additional PSF Models for WFC3

Zoey Mancuso de Lopez *New Mexico Institute of Mining and Technology*

Mentor – *Varun Bajaj (Senior Staff Scientist, Science Support)*
Co-Mentor – *Dr. Sylvia Baggett (WFC3 Branch Lead), Frederick Dauphin (Science Support Analyst)*

The library of HST Wide Field Camera 3 (WFC3) point spread function (PSF) models developed by J. Anderson are a valuable resource for image analysis, providing the ability to fit stellar fluxes and positions to extremely high precision. Because the PSF varies with wavelength as well as other properties of the optical elements, the models must be created with spatial and filter dependence. While the current models have good spatial coverage, they cover only some of the most used, wide-band filters. Leveraging the database of star cutouts in the MAST Archive and modern PSF construction tools, we will develop models for the next-most-often-used WFC3 infrared filters, to further the applicability of the existing PSF fitting and analysis tools.

Design of Segmented Telescope for HiCAT Testbed

Joe Lugten *University of Rochester*

Mentor – *Rémi Soummer (Director of Russell B. Makidon Optics Laboratory)*

The Makidon Optics Lab at STScI works on the research and development of technology for future space missions. Currently, the main focus of the lab is on coronagraphs, which suppress starlight in order to study exoplanets and other faint objects. The High-contrast imager for Complex Aperture Telescopes (HiCAT) is a testbed designed to demonstrate an end-to-end coronagraphic system with the extremely high contrast required to directly image Earth-like exoplanets. This requires advanced wavefront control and starlight suppression with the segmented-aperture geometries required for large space telescopes like LUVOIR, NASA's next flagship mission. This project involved an instrumentation upgrade of the HiCAT testbed, replacing the current telescope simulator with a small off-axis Cassegrain telescope. This more accurately resembles a real space telescope and allows us to study how the system reacts to and compensates for telescope misalignments and drifts. This project involved design and tolerancing in Zemax, as well as work in SolidWorks, to visualize the telescope's integration with the current HiCAT testbed. Prototypes of the telescope will be built this fall, with a full telescope hopefully following soon after.

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

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"COSMIC CLIFFS" IN THE CARINA NEBULA
(NIRCAM IMAGE)