#1 Mira Mahendru, Boston College

Title: Understanding the Giant Resistivity Peak and Negative Magnetoresistance in Zintl Compound EuCd2P2

Abstract: Colossal negative magnetoresistance (nMR) has been observed in various Eu-based Zintl compounds; an outstanding example is EuCd2P2. Several different mechanisms such as spin fluctuations, strong spin-carrier interactions, BKT transition, and band reconstruction were predicted to be involved in producing nMR in EuCd2P2. Here we report observation of two different kinds of high temperature resistivity behaviors: an insulating trend and a bad metallic trend in different samples of EuCd2P2. Samples which display an insulating trend show very large resistivity peaks at lower temperatures compared to bad metallic samples. We present the heat capacity, magnetoresistance and carrier concentration data comparing these two samples. Our results can shed light on the microscopic mechanism of nMR in EuCd2P2.

#2 Deepika Kumawat, Mount Holyoke College

Title: Optical Characterization of AgCrP2S6

Abstract: AgCrP2S6 is an interesting 2D material that features chains of silver and chromium atoms that behave like 1D materials. Below 21 K, the chromium atoms order antiferromagnetically, making it a unique magnetic system. The goal of the project is to determine the band gap of this semiconductor. Despite the difficulty of using optical probes on ultra-thin materials, we have developed methods to calculate the transmission, reflectivity, and photoluminescence in order to determine photoabsorption. We have measured the band gap to be 1.3 eV in excellent agreement with DFT calculations.

#3 Kianna Cabral, Northeastern University

Title: Post-Quantum Group-based Cryptography: Breaking Xifrat

Abstract: In recent years, The National Information Technology Laboratory (NIST) has been calling for a transition to post-quantum cryptography. With the rapid advancement of quantum computers, established cryptographic methods are at risk of being compromised. Traditional public-key cryptosystems can no longer ensure the confidentiality and integrity of digital communications. As a potential solution to this challenge, Xifrat1-Sign, a digital signature scheme based on quasigroups, has been proposed to NIST. By leveraging the special properties of the algebraic structure of quasigroups, and particularly, the restricted-commutativity, this cryptographic scheme aims to achieve a quantum resistant security. To assess its effectiveness, we conducted a cryptanalysis of the Xifrat cryptosystem using computational group theory and differential statistical analyses. As a result, we identified several vulnerabilities in its design and were also able to break the full system in seconds. This study not only makes a significant contribution to the improvement of the Xifrat cryptosystem and other quasigroup-based schemes, but it also contributes to the reinforcement of new cryptographic frameworks in the face of emergent quantum technologies.

#4 Allison N Brattley, Massachusetts Institute of Technology

Title: Teleportation with Two Interacting Species of Ultracold Atoms in a Ring Lattice

Abstract: We consider two species of interacting ultracold atoms in a toroidal trap with effective one-dimensional azimuthal dynamics, show that that dynamics can be described in terms of collective spin operators, comprising of terms linear and quadratic in those operators. The quadratic terms can generate a high degree of quantum entanglement. We determine the stationary properties, including a complete set of commuting variables and the density of states. We describe a mechanism to use the strong entanglement in a multiplicity of such ring systems to implement continuous variable quantum teleportation. We compare the fidelity of this mechanism to a counterpart when entanglement is absent and determine regimes of quantum advantage.

#5 Lucy Nathwani, Harvard University

Title: Using Machine Learning to Solve Schrödinger's Equation in 1D

Abstract: We explore the application of deep learning techniques to solving Schrödinger's equation in one dimension. In this study, we train neural networks using a loss term derived from Schrödinger's equation to produce closed-form time-evolving solutions. We introduce a Gaussian position envelope and an initial condition term to maintain the boundary conditions of the problem, and our parameterized network produces the real and imaginary components of the wavefunction that comprises our solution. We apply this method to potentials with closed-form solutions, such as the infinite square well, quantum harmonic oscillator, and Morse potentials. The network effectively modeled time evolution under these potentials for increasingly complex initial conditions, demonstrating its adaptability. The goal is to apply this technique to more complicated and realistic potentials, making deep learning a valuable tool in materials modeling and many-body quantum problems.

#6 Francesca Paloma Rodriguez Thorne, Bates College

Title: High Precision Laser Frequency Measurements for Ultracold Atomic Physics Experiments

Abstract: At Lundblad Lab, we conduct ultracold atomic physics experiments by cooling rubidium (Rb) atoms using laser cooling techniques. By directing lasers towards a cluster of Rb atoms, we decrease their momentum and cool them close to absolute zero. Our focus is on Bose-Einstein Condensation (BEC), where atoms are cooled to their lowest energy level and behave as a single quantum entity. We control laser frequencies with Fabry-Perot Interferometers (FPIs), which detect the interference of light. To enhance our experimental capabilities, we integrated a high-resolution Fabry-Perot Interferometer (FPI) into our laser system, enabling precise control of laser frequencies.

To capture images of ultracold atoms, we use the probe laser and a technique called frequency modulation, where we rapidly shift laser frequency back and forth around the desired central frequency. With the new FPI, we were able to visualize and analyze the data to determine the optimal amount of amplitude modulation of the probe laser that would ensure a frequency shift within the desired threshold

of Rb atoms. This improves the clarity of BEC imaging and enhances the overall data collection and imaging system in our lab.

#7 Warisa Jaidee, Wellesley College

Title: Quality assurance of Macro-Pixel Sub-Assemblies (MaPSA) before installation in CMS

Abstract: The High Luminosity upgrade for CERN's LHC will replace CMS silicon tracking detectors with PS modules, consisting of one strip sensor and one macro-pixel sensor. The Macro-Pixel Sub-Assembly (MaPSA) requires thorough testing of each pixel for optimal performance. This project aims to develop an efficient data handling system for MaPSA quality assurance, enabling performance tracking of each MaPSA's pixel through an accessible database before installation into the CMS outer tracker.

#8 Fadhimah Mohamed, Hamline University

Title: Thermal analysis of lithium-ion batteries using computational fluid dynamics.

Abstract: In the midst of a significant shift towards renewable energy sources, the pivotal role of lithium-ion batteries has emerged as the backbone of a sustainable future.These batteries have become integral components in an array of applications, from electric vehicles to portable electronics due to their high energy density and efficiency. However, as society continues to move further into using renewable energy, the spotlight on effective Battery thermal management (BTM) intensifies. Ensuring the optimal performance and longevity of lithium-ion batteries is not only crucial for enhancing the efficiency of clean energy systems but is also central to addressing the challenges posed by heat dissipation.This research focused on a comprehensive thermal analysis of lithium-ion batteries, concentrating on effectively managing the dissipation of heat generated during the battery operation. Using computational fluid dynamics (CFD), we simulated heat generation characteristics and volume average temperatures of a lithium iron phosphate ($LiFePO_4$) battery during 1C to 3C charging and discharging cycles. These simulations were subsequently compared with experimental data acquired from a thermal camera.

#9 Helena Beeloo, Bridgewater State University

Title: Exploring the Binding Kinetics of Chemotherapeutic Mitoxantrone to DNA using Optical Tweezers

Abstract: Mitoxantrone (MTX), a synthetic derivative of Doxorubicin, is a chemotherapeutic drug that prevents DNA replication by intercalating between the DNA base pairs. Combined with its additional mode of action as a TOPO-II poison, MTX is an integral therapy for cancers such as acute leukemia, lymphoma, prostate cancer, and advanced stage breast cancer. It is additionally used at low doses in the treatment of severe multiple sclerosis. The interactions of micromolar concentrations and higher of MTX have been studied previously with both conventional methods and single molecule methods. However, there is a lack of information on the effect of nanomolar concentrations, and lower, on DNA. In this study, we used dual-beam optical tweezers to trap single molecules of DNA and stretch them in the presence of MTX. This method allowed us to characterize molecular level interactions between the drug and DNA at these low concentrations. We used constant force experiments to quantify the binding kinetics of MTX. During constant force experiments, a single DNA molecule was stretched to a specific force and held at constant

tension until MTX binding reached equilibrium with the DNA molecule. The major outcome of the preliminary single molecule studies suggest MTX intercalates with DNA at nanomolar concentrations. The completion of this project may prompt future studies on the therapeutic effect of the drug at low dosages and more insight to its binding mechanism to DNA.

#10 Milagros Tamara Giraldo, Bridgewater State University

Title: Photometry of Asteroids and Fourier Analysis of Lightcurves

Abstract: This research measures the rotational period of 1088 Mitaka around its axis. By using the images gathered by the BSU observatory team. Performing photometry on them to generate its lightcurve, and using this measurement in Fourier Analysis to calculate the rotational period of the asteroid. As the obtained result is compared to the known rotational period of 1088 Mitaka (3.03 hours) a percent error of 3.6% was calculated.

#11 Annie Clark, College of the Holy Cross

Title: A Minimal Higgs Portal Dark Matter Model Under Current Experimental Constraints

Abstract: Dark matter (DM) constitutes approximately 26.8% of the energy density in our universe, and the only concrete evidence we have for its existence is its effects on matter that we can sense. Some prudent examples include galaxy rotation curves and the cosmic microwave background. In galaxy rotation curves, there is an excess of mass that keeps the velocity constant; this mass cannot be seen or touched. The CMB emits light throughout our universe, which happens to be bent. These two examples demonstrate that although DM cannot be seen, its effects are felt throughout the universe. Scientists have postulated different theories for DM, but one of the best candidates are weakly interacting massive particles (WIMPs). WIMPs are non-baryonic and electromagnetically neutral, with masses in the GeV to TeV range, and they are detected using nuclear recoil. Researchers know of their existence by witnessing nuclei shake after interacting with a WIMP.

The Higgs portal DM model falls under the umbrella of WIMPs. This model opens a portal between DM and the Standard Model (SM). Essentially, the DM particles interact with the 125 GeV Higgs, which then decays into SM particles. However, there is also an invisible portion of the Higgs decay, which may be connected to DM. In this study, we utilized a minimal Higgs portal DM model, meaning the DM candidates interact with only one 125 GeV Higgs, as opposed to multiple. This model adds a Z2-odd scalar field, which ensures that the DM candidates are stable and will not decay. Our goal is to analyze the connection between the branching ratio of the invisible decay of the Higgs to the mass of the DM candidates and the connection between the abundance of the DM candidates and their masses.

#12 Isadola Steinman, Amherst College

Title: The Creation and Observation of Three-Dimensional Skyrmions in Spin-2 Bose-Einstein Condensates (BECs)

Abstract: This summer, I attempted to create and photograph a three-dimensional topological excitation known as a skyrmion that occurs in BECs in particular magnetic phases subject to a particular magnetic field configuration. A BEC is a superfluid state of matter that forms when dilute bosonic gases are billionths of a degree above absolute zero and when their atoms are in their lowest energy state or ground state. We study BECs because they are macroscopic but exhibit behavior identical to quantum phenomena that is more difficult to observe. We particularly study topological excitations—structures that cannot be deformed continuously—because they have applications in quantum computing, astrophysics, and cosmology. A skyrmion is a three-dimensional particle-like topological excitation we make in BECs.

Our BECs can be described by a magnetic phase at every point. The two magnetic phases we used to make skyrmions were biaxial nematic and cyclic-tetrahedral. By rapidly changing our apparatus' magnetic field in a particular way, we manipulate the magnetic phase of the BEC in a way that imprints the skyrmion in the BEC. After many adjustments to the initial magnetic phase preparation and the apparatus' magnetic field, we successfully created and imaged fully wound biaxial nematic and cyclic-tetrahedral skyrmions in spin-2 BECs. These skyrmions are more complicated than those that have been previously observed, and this summer, we took some of the clearest images of these skyrmions to date.

#13 Kathryn Brockmeyer, Williams College

Title: The Randomness of Rain

Abstract: The local spatiotemporal structure of rainfall is of critical importance to radar-based measurements of weather, erosion prediction, splash-based plant and fungal reproduction, and other droplet scale processes. Past studies using optical disdrometers (2DVDs) have observed structure in rain on the spatial scale of storms and rain cells, but little is known about the droplet scale due to tapering instrument resolution. In this work, we directly image raindrop arrival times and locations to investigate patterns and interactions on the centimeter scale. We analyze the droplet fall pattern through a pair correlation function and calculate a fractal dimension to determine spatial and temporal clustering. We hypothesize that raindrops will cluster as a function of drop size distribution and therefore storm type, convective or stratiform. We aim to apply our results on rain patterning at the smallest scale to understanding splash-based reproduction in early land plants.

#14 Kateryna Havryshchuk, Amherst College

Title: Fractional Vortex Creation in Bose-Einstein Condensation at Low Field

Abstract: Our group works on developing fractional, in particular half- and third-quantized, vortices in the Bose-Einstein Condensation (BEC) at low field. The research we carry out explores the evolution of such topological excitations in the BEC and has the potential to solve vortex mysteries of superfluids, superconductors, neutron stars, and even quantum computers. Often referred to as the fifth state of matter, the Bose-Einstein Condensate (BEC) in our lab appears from the cloud of Rb-87 atoms cooled down to almost an absolute zero and highly condensed. Due to the BEC physical properties, the quantum state of atoms throughout the condensate must either remain the same or change gradually. This makes the BEC an appropriate environment for creating, observing, and analyzing quantum vortices. While the state changes only once around the vortex in singly-quantized structures, sometimes such structures break into less energetic half- and third-quantized (i.e., fractional), which are characterized by the half-

and third-quantum rotation of the state around the vortex core. Such vortices can be developed by first creating singly-quantized vortices in the spinor-2 condensate of the proper magnetic phase and then letting the system evolve in time. However, the magnetic field required to trap the atoms may stand in the way of collecting high-quality data. The higher the field, the harder it is to observe the condensate spinor properties and justify the spinor nature of the fractional vortices. Our team aimed to develop the discussed topological excitations in the lower field. We have already succeeded in creating half-quantized vortices in the biaxial nematic magnetic phase of the condensate at the five times less strong magnetic field. We've developed a program to analyze the resultant images based on the magnetic properties of the components. This helped us visualize the fractional essence of the phenomenon and register the component oscillations between the magnetic phases—the undeniable proof of the vortex spinor nature. Moreover, the lower field also allowed us to study the condensate transitions from point-up to face-up states with time evolution. So far, we have concluded that fractional vortices in the Bose-Einstein Condensate can be developed, analyzed, and sustained at relatively low magnetic field values. By observing the condensate components' oscillations between magnetic phases, we have proven the spinor nature of the vortices and dispelled doubts about the possibility of their creation in lab settings. While having succeeded with half-quantized vortices, we still need to improve the state preparation and image analysis technologies to create third-quantized vortices in the cyclic-tetrahedral phase in the future.

#15 Sonya Dutton, Williams College

Title: Towards a Narrow, Ultrastable Diode Laser for Sideband Thermometry of Trapped Sr+

Abstract: Advances in the control of electrical currents in the last century have fueled the information revolution. Control of thermal currents is poor in comparison, particularly at mesoscopic scales similar to digital electronics. Our lab aims to build a tunable system of co-trapped Ca+ and Sr+ and study heat transport on an ion-to-ion scale. This involves constructing a suite of lasers to trap and manipulate Sr+, including an external-cavity diode laser to measure the 'temperature' of individual ions through sideband thermometry. This laser, which must have a narrow linewidth and be stable enough in time to drive an E2 transition, has a new interference-filter stabilized design and will be locked to an ultralow-expansion cavity using the Pound-Drever-Hall technique. We discuss progress in laser design, construction, and integration with the existing setup.

#16 Zeineb Mezghanni, Grinnell College

Title: Shedding Light on Dark Matter using Stellar Streams

Abstract: Dark matter (DM) makes up about 84% of the matter budget in our universe. However, understanding its nature has been one of the most significant challenges in modern physics as it only interacts gravitationally with baryonic matter. DM effects influence the formation and evolution of cosmic structures, such as Stellar Streams. Stellar streams are remnants of disrupted star clusters or dwarf galaxies stretched out into elongated structures. They are remarkably sensitive to perturbations and their analysis provides valuable insights into the distribution and properties of DM in galaxies. In this work, we study the morphological differences of stellar streams under cold dark matter (CDM) and self-interacting dark matter (SIDM) models to understand the effect of DM on tidal disruption. Such DM models are well motivated and might explain some of the discrepancies in observations. We use semi-analytical methods to generate galaxies with the GalIC code and run isolated simulations of mergers using Gizmo. Finally, we

build a catalog of stellar streams under different DM assumptions. The resulting work can facilitate further analyses of the Milky Way's merger history and DM effects on structure formation.

#17 Sara Tulchinsky, Wellesley College

Title: Modeling Ferroelectric Domain Nucleation for Scalable, Energy-Efficient Microelectronics

Abstract: Ferroelectric (FE) materials are a unique class of materials that can maintain a spontaneous, reversible electric polarization without a constantly applied electric field. In a FE, small regions of polarization called domains complete the polarization switching during a two-step process: nucleation, where the domain reaches a critical size ("critical nucleus"), and growth, where it grows to fill the FE. Because of their exotic properties, FE oxides offer crucial applications for energy-efficient logic and non-volatile memory devices. However, current FE capacitors are multi-domain structures, much larger than the size of one critical nucleus, which limits their maximum efficiency due to the lengthy domain growth process that must occur to switch the device. A capacitor with thickness and lateral area that are close to the size of one critical nucleus–where nucleation dominates switching–would switch faster and with less energy. To address this, we developed a nucleation model for the canonical FE material Barium Titanate ($BaTiO_3$), using the Janovec-Kay-Dunn (JKD) model as framework for computation and simulation. The results of our work provide the critical radius and free energy of a single $BaTiO_3$ domain nucleus along with a map of the energies that dominate its nucleation. We are also able to adapt our model to match recent experimental results that suggested a deviation from JKD scaling for ultrathin $BaTiO_3$. We report challenges in simulating a critical length and also in reproducing the experimental results in our lab for the FE material PMN-PT. Overall, there is much room for future work on this topic, and our simulation can be adapted for a variety of FE oxides. We demonstrate progress toward the specification and fabrication of a monodomain FE capacitor for the development of scalable, high-performance neuromorphic ("brain-based") computing systems.

#18 Emma Rabinowitz, Tufts University

Title: Determination of Beta Sheet Fraction of Regenerated Antheraea Pernyi Films Using FTIR and FSD

Abstract: Silk has become a popular biomaterial due to its biodegradability and the favorable mechanical and thermal properties of the protein, fibroin, that makes up the silk fiber [1]. These properties are due to the presence of crystalline secondary structure, beta pleated sheets. Therefore, the beta sheet fraction of silk fibroin has great implications for its properties and potential biomedical usage. While most research on silk fibroin crystalline structure has been done on domesticated Bombyx Mori silk, the properties of silk from wild-type silkworms that have had to face a variety of different environmental threats has been largely unexplored [2]. This study examines the properties of the wild-type silk, Antheraea pernyi. The beta sheet fraction of regenerated A. pernyi silk fibroin films prepared in different ways was determined using Fourier transform infrared spectroscopy and Fourier self-deconvolution of the amide I region of the infrared spectrum. Beta sheet fractions for silk films prepared with varying dissolution and dialysis times were found ranged from 0.25 to 0.41. Fast scanning calorimetry at 1000 K/s showed that A.pernyi has a very high glass transition temperature of ~ 250 C.

[1] Hu, Xiao, et al. "Determining beta-sheet crystallinity in fibrous proteins by thermal analysis and infrared spectroscopy." Macromolecules, 2006, 39(18), 6161–6170.

[2] Guan, Juan, et al. “Comparing the Microstructure and Mechanical Properties of Bombyx Mori and Antheraea Pernyi Cocoon Composites.” Acta Biomaterialia, 2016, 47, 60-70.

#19 Shreya Gandhi, Dartmouth College

Title: Analyzing the Aurora: Unveiling Insights in LAMP Data

Abstract: Electrons traveling from the sun in the solar wind interact with ions and electrons in Earth's ionosphere, giving rise to the aurora. Pulsating aurora, in which auroral structures appear strobe-like, are a little-understood phenomenon in space physics, which motivated NASA's 2022 LAMP (Loss Through Auroral Microburst Pulsations) sounding rocket mission. One of the instruments aboard the LAMP flight, which flew through pulsating aurora over Poker Flat, Alaska, was a Petite-Ion Probe (PIP). Data collected by PIPs is supplemented by ground-based and in-situ measurements from various other instruments including but not limited to larger radar systems' imagery. Conducting a detailed analysis of the data collected by the 8 Dartmouth PIPs aboard the flight has helped determine key plasma parameters after parsing data and examining survey plots. The Levenberg-Marquadt nonlinear least squares minimization algorithm has provided an avenue to fit the data and look at signatures of electron precipitation during LAMP's flight -- this algorithm was designed to find scalar plasma parameters of ion temperature, density, and spacecraft potential. Comparisons between fits and ground-based radar data appear to suggest that electron precipitation during the flight has locally reduced flow in the ionosphere. Large-scale radar across the region may not be able to detect small-scale localized flows: the effects of electron precipitation may be overlooked, underscoring the importance of small low-resource instruments like the Dartmouth PIP aboard future rocket missions, and this continued work will inform LAMP-II, a follow up mission, in its design.

#20 Estefany Lopez-Velazquez, Williams College

Title: Dark Count Rate Measurements for DarkSide-20k Dark Matter Detection

Abstract: The DarkSide-20k experiment aims to detect dark matter in a liquid argon time projection chamber. The DarkSide-20k detector will use 20 square meters of silicon photomultipliers (SiPMs). My research is focused on the precise measurement of a crucial SiPM parameter, the Dark Count Rate (DCR). At Williams, we are developing a dedicated experimental setup to measure DCR at liquid argon temperature. Our goal is to characterize a selection of DarkSide-20k SiPMs and qualify them for use in the experiment.

#21 Michelle Sangillo, Worcester Polytechnic Institute

Title: Investigating drivers of winter wave events in the Alaskan Arctic

Abstract: In the Arctic summer, landfast sea ice protects the coasts from the ocean waves that are generated in ice-free waters offshore. In the Arctic winter, continuous ice cover prevents offshore wave generation, but openings in the landfast ice can cause localized wave events near the coast. We explore six of these wintertime wave events recorded by a seafloor mooring off the coast of Flaxman Island, Alaska, as part of the Coastal Ocean Dynamics in the Arctic (CODA) project in 2019-2020. We focus on the

sea ice and atmospheric conditions associated with these events by combining observational data, reanalysis data, and satellite imagery. Atmospheric conditions examined include wind speed, wind direction, near-surface temperature, and surface pressure from the ERA5 reanalysis product. Days of winter wave events have statistically significant stronger easterly winds, higher air temperatures, and lower surface pressures compared to the entire winter. However, these conditions do not guarantee the occurrence of winter waves. The presence and length of an open-water fetch is essential for wave growth. Fetches along the average daily wind direction were measured from NASA Worldview and used with average daily wind speeds to calculate expected significant wave heights at the mooring location. Mismatches between calculated significant wave heights and average observed significant wave heights are most likely due to limitations in the features from NASA Worldview's satellite imagery. Results suggest that winter wave events correspond with openings between landfast sea ice and pack ice under low-pressure atmospheric systems with easterly winds. The conditions that correspond to winter wave events at different locations in the Alaskan Arctic likely vary based on the geometry of the coastline. These results may be helpful in predicting conditions favorable for landfast ice breakup.

#22 Haedam Im, Massachusetts Institute of Technology

Title: Atmospheric Inflation of Exoplanets Undergoing Tidal Heating

Abstract: High eccentricity and large planetary spin-axis tilts can lead to distortion of the planet's structure, leading to energy dissipation in the form of tidal heating. Therefore, the planet's atmosphere is inflated compared to its state in the absence of tides. This paper provides a population analysis of radius inflation due to tidal heating for exoplanets within the "Savanna" regime (roughly 4 $R_\oplus < R_p < 10 R_\oplus$; 5 days < P < 30 days), analyzing the ratio of the radius with and without tides $R_{p,ratio}=R_{p,t}/R_p$. We conclude that the population close to the lower boundary of the Savanna regime would have been placed within the dense population of planets of $R_p < 4 R_\oplus$ without the presence of tidal inflation. We further explore the implications of radius inflation on the cause of the dearth of exoplanets in the Savanna region. Along with the population analysis, we present specific case studies of radius inflation for the TOI-4010 system, three exoplanets in the Neptune desert (TOI-674 b, TOI-532 b, TOI-3785 b), and two young exoplanets (K2-411 c, AU Mic b).

#23 Madison VanWyngarden, Boston University

Title: Modeling Multiple Radius Valley Emergence Mechanisms with Multi-Transiting Systems

Abstract: Close-in planets smaller than Neptune are observed in two distinct populations: rocky planets with radii < 1.7 $R_\oplus$ and planets with rocky cores surrounded by thick H/He envelopes with larger radii. Whether this bimodal distribution, separated by a drop in occurrence known as the radius valley, directly results from planetary formation or from subsequent atmospheric escape processes, remains unconfirmed. To address this issue, we develop models to test XUV-driven photoevaporation, core-powered mass loss, and an accretion-limited primordial radius valley model using systems containing multiple planets spanning the radius valley. Focusing on multi-transiting systems allows us to eliminate unobservable quantities that are shared within individual systems such as stellar XUV luminosity histories and the properties of the protoplanetary disk. We test each proposed radius valley emergence mechanism on all 221 known multi-transiting systems and calculate the minimum masses of the systems' enveloped planets to be consistent with the models. We compare our model predictions to 75 systems with

measured masses and find that the majority of systems can be explained by any of the three proposed mechanisms. We also examine model consistency as a function of stellar mass and stellar metallicity but find no significant trends. More multi-transiting systems with mass characterizations are required before multi-transiting systems can serve as a viable diagnostic of radius valley emergence models. Our software for the model evaluations is available on GitHub and may be applied to future multi-transiting system discoveries.

#24 Ava Frost, Mount Holyoke College

Title: The Solar Wind Interaction with the Planet Venus: Mapping Conditions Favorable for Energy Transfer to the Ionosphere

Abstract: We used spacecraft measurements made at the planet Venus to understand how our Sun interacts with the planet and other bodies in our solar system. Using over 14 years of collected data from the Pioneer Venus Orbiter (PVO) spacecraft, we mapped the interaction between the solar wind and Venus. We focused in particular on its atmosphere and its charged component known as the Ionosphere. We analyzed several parameters, including the magnetic field strength and electron density, to create a picture of the space environment around Venus. Analysis of these parameters allows us to determine if conditions are favorable for specific processes to occur that transfer energy from the solarwind to the Ionosphere. This study focuses on the specific process known as "Magnetic Pumping". These same processes have been shown to occur at Mars due to its lack of a magnetic field and Ionospheric conditions. This process could also occur at Venus because the space plasma environment has similar characteristics. Utilizing case studies such as Venus and Mars allows us to better understand the fundamental physics behind such energy transfer processes and better understand how a planet interacts with the space environment. Our solar system acts as a natural laboratory and enables comparative studies with systems we cannot reach in situ, such as exoplanets and how they interact with their host stars.

#25 Sona Hanslia, Worcester Polytechnic Institute

Title: Temperature Imaging of Diamond-Glass and Diamond-Aluminum Interfaces with a Quantum Diamond Microscope

Abstract: Quantum sensors comprised of Nitrogen-Vacancy (NV) centers in diamond are an emerging technology for imaging magnetic fields with sub micro-Tesla sensitivity and micron-scale spatial resolution. Our aim is to develop a new application for the Quantum Diamond Microscope (QDM) with NV diamond to characterize the magnetic properties of novel biomaterials comprised of iron-chelation silk microfibers. These biomaterials can be controlled by external magnetic fields and have applications in tissue engineering. Thus, magnetic characterization is critical. However, magnetic imaging with a QDM is challenging because the biomaterials can be burned by the required laser illumination and fluorescence of the NV centers. We did thermal simulations and designed a mount that minimizes sample temperature. Using a QDM, we experimentally imaged temperatures with the NV diamond on an aluminum block versus a glass microscope slide that is traditionally used. We compared the temperature distribution of the two interfaces using diamonds with 7ppm, 4.5ppm, and 3ppb densities of NV centers. Aluminum reduced the average temperature of the 7ppm and 4.5ppm NV diamonds by 20 °C, and we experimentally demonstrated a similar effect with the sample as well. Thus, swapping the glass slide for an aluminum

block allows us to increase the laser power, and in turn reduce measurement error and increase magnetic field sensitivity to allow for magnetic imaging of a wider range of heat sensitive samples.

#26 Catherine La Riviere, Wellesley College

Title: Topology and Kinematics of Arch Disclinations in 3D Nematic Liquid Crystals

Abstract: Understanding the structure and motion of disclinations in nematic liquid crystals is vital to understanding the evolution of nematic systems. This project investigated the topology and predicted the velocity of an arch disclination in a 3D nematic liquid crystal. We characterized the topology of a stable arch disclination from an anchored +½ and -½ defect pair to a surface in a three-dimensional system. We then found the velocity of the disclination following applied shear by applying the kinematic law of disclination line motion derived by Schimming & Viñals, verifying its effectiveness for arch disclination lines.

#27 Jennifer Doyle, Wellesley College

Title: Studying crystal growth particle-by-particle via self-assembly simulations

Abstract: Observing the process through which crystal structures self-assemble spontaneously can allow for the creation of novel materials with greater complexity and control in structure. Existing theories can be further developed to properly generalize our understanding of the process of particle-by-particle attachment by using multi-well isotropic pair potentials to simulate four different structures in two-dimensional systems ranging in size from 3 to 20 particles. We find a general tendency toward hexagonal order at small system sizes, which persists before reaching each system's bulk structure. In the triangular and square lattice systems, the structure as predicted in the bulk requires a certain number of particles, 9 and 12 respectively, once this number is reached the system will tend towards their predicted structure.

#28 Treya Pember, Wellesley College

Title: Near-Infrared Observations of Accretion Signatures in Low-Mass Accreting Objects

Abstract: The process through which young stars gain mass, known as magnetospheric accretion, is a well-understood phenomenon in which material from the star's circumstellar disk (CSD) is funneled along its magnetic field. This infalling gas reaches temperatures capable of stimulating line emission from recombining hydrogen atoms. These line emissions can then be detected and measured to determine accretion activity. For the low-mass regime, including planets, brown dwarfs, and low-mass stars, the physical process responsible for producing hydrogen emission is potentially different from magnetospheric accretion. In order to test the applicability of the magnetospheric accretion paradigm for young, substellar-mass objects, we collected moderate-resolution near-infrared spectra of four targets. Our observations of low-mass targets in the near-infrared detect and measure hydrogen emission, allowing for further characterization of the relationship between emission line luminosity and the mass accretion rate. In a survey including our observations and previously observed data, we detect accretion signatures Paschen β, Paschen γ, and Brackett γ from five brown dwarfs. We present preliminary measurements of line strengths

and calculate accretion luminosities and mass accretion rates according to relationships predicted by magnetospheric accretion models.

#29 Caitlin Pestana, Bridgewater State University

Title: The Development of The Bridgewater State University Observatory Public Research Database

Abstract: We are in the process of making over a decade's worth of astrophysical research images and photometric data taken at the Bridgewater State University Observatory accessible to the public. The data are the result of student-driven investigations, encompassing a wide range of astrophysical subjects including reverberation mapping, measurement of Type Ia supernovae, exoplanet transits, and studies of periodicity. We sought to create a website that can house the data in an accessible way for public utilization across a wide range of skill levels. Over the course of the spring and summer of 2023, we developed our online database, standardized and uploaded data from Jan.-May 2023 and June-Dec. 2022, and structurally reorganized our recently developed variable-star identifying Python program "VaRSL" written by Caleb Derochea. We posted data within dated repositories to GitHub and organized links to each by object on the website's homepage. We expect to automate this process, add photometric measurements and characterization from VaRSL in each repository, and generate educational materials to support users of varying experience levels in the future.

#30 Kyara Soto Villlarreal, Smith College

Title: Accretion in Low Mass Stars with Traditional Disks

Abstract: I am doing spectroscopy in protoplanetary disks of low mass stars. I am working with iShell data high resolution infrared data. The data was taken in the bands J0 (1.065–1.116 µm), J3 (1.27–1.36 µm), K2 (2.09–2.38 µm). I worked with reduced and corrected data from the objects DmTau, J022441, V410, and ZZ Tau. I identified accretion indicators in the spectra: Paschen γ, Paschen β, Brackett γ and HeI. The HeI at λ10830 Å is particularly interesting to measure accretion, as it can also indicate the direction of the gas, and here I present the morphology of the lines for the mentioned objects. I calculated the flux using Paschen γ and Paschen β and calculated accretion rates for all my objects.

#31 Kaiya Wilson, Wellesley College

Title: Characterizing Single-Photon Emitters in Hexagonal Boron Nitride

Abstract: Single-photon emitters are important building blocks for quantum technologies which can be observed in many different materials. Defects in the 2D material hexagonal boron nitride are particularly interesting candidates for single-photon emission due to their variety of emitters with different wavelengths at room temperature. In this research, we located and studied emitters on various hBN samples with the ultimate goal of identifying a stable and strong single-photon emitter. We located and characterized potential emitters using photoluminescence and purity measurements. Using this process, we were able to witness single-photon behavior in some emitters, though the purity measurements are

difficult to interpret. Our results are a starting point for a continued hunt and encourage the future study of hBN defects as single-photon source candidates.

#32 Marcela Silvera Tafur, Wellesley College

Title: Studying the Thermodynamic Effects of Non-Canonical DNA using Optical Tweezers

Abstract: The natural form of DNA is a double helix formed by covalent phosphodiester bonds that attach nucleotides along each strand and hydrogen bonds that connect the nitrogenous bases between complementary strands. Although the structure of DNA is very stable, it is constantly exposed to sources of reactive oxygen species (ROS), which can lead to covalent modifications, destabilization of the natural double helix form, and permanent mutations. To study the thermodynamic properties of these lesions, we use non-canonical DNA hairpins designed based on the Trans Activation Response (TAR) element RNA found in the HIV-1 virion.

DNA hairpins are palindromic sequences that create stem-and-loop structures resembling bobby pins. Our DNA hairpins consist of a loop containing single-stranded DNA connected with a length of 6 nucleotides and a double-stranded base-paired stem containing 29 base pairs. For this research project, DNA hairpins are used as a model for double-stranded DNA. They are studied with the application of force from single-molecule force spectroscopy experiments to understand better the thermodynamic and kinetic properties of small molecules like DNA. One of the force spectroscopy experiments used in this project is Optical tweezers, which employ a dual-beam laser trap and a flow cell with complementary ligands to the DNA hairpins. The optical tweezers' components catch and trap the DNA hairpins' ends, and force is applied to the hairpins, producing an unzipping occurrence and generating a force-distance curve. The force necessary to unzip or open a hairpin determines the base composition and stability, providing information about the hairpin's thermodynamic stability. Different hairpins can be composed of various base pair lengths or base pair mutations like oxidized guanines, 8oxoG-C, and 8oxoG-A, which usually results in a destabilization of energy (kbT).

#33 Abigail Rothstein, Simmons College

Title: The effect of the temporal bone on ultrasound transmission

Abstract: Focused ultrasound (FUS) has shown great promise in the field of neuromodulation. FUS is under investigation as a novel treatment for mesial temporal lobe epilepsy (MTLE) through modulating the hippocampus. We will investigate the loss of energy transmission through a series of locations along a segment of ex vivo human skull to determine the most effective treatment paths. Experimentally, a 0.5-MHz planar transducer will be used to sonicate through two segments of ex vivo human temporal skull bone. By analyzing the axial plane, we will be able to identify the locational shift of the energy. After successful transmission measurements of the temporal bone specimens, we will perform comparative analysis with simulations created using the Matlab package kWave. The resulting data will represent a simulation of what is predicted to happen when ultrasound passes through that area of the skull.

#34 Sonia Mulgund, Wellesley College

Title: Structural Investigation of Chiroptical Assemblies of Cadmium Sulfide Magic-Size Clusters

Abstract: Much of the natural world is characterized by self-assembled structures across many orders of magnitude. For example, biological systems have exceptional levels of hierarchical organization. Multiple levels of structure allow for multiple levels of tunability and function. Thus, one field of study in materials science today is the development of new self-assembling systems. When synthesized at high concentration, cadmium sulfide magic-size clusters (MSCs) form a fibrous mesophase. This structure has nanometer-scale organization, forming hexagonal arrangements of MSCs that connect in fiber bundles. It also has centimeter-scale structure, with the ability to create neatly ordered diffractive thin films. However, specific mechanisms of mesophase formation are yet to be elucidated. Here, we investigate the role of oleic anhydride (a synthetic byproduct) in the MSC mesophase by developing an understanding of oleic anhydride's own ability to self-assemble into fibers. The roles of the anhydride species and ligands were also investigated via MSC synthesis with alternative carboxylic acid ligands. Finally, the self-assembly behavior under different evaporation conditions was investigated via dip-drying of thin films. Oleic anhydride was shown to play an important role in mesophase formation. This understanding of the mesophase structure and mechanisms of its formation will inform potential applications and extensions to new systems.

#35 Iman Khanani, Mount Holyoke College

Title: Printing carbon nanotube bioFETs for electrical detection of target biomarkers

Abstract: The prevention of rapidly spreading diseases does not begin with finding the cure, rather it starts with the ability to accurately detect the disease as quickly as possible. Current methods of detecting diseases are typically slow, expensive, and require advanced laboratories with centralized bulky machines, rendering the detection of diseases to be inaccessible and time-consuming. Thus, there is a need for an easy to use, accurate, and inexpensive way to detect diseases. This necessity led to a strong interest in the development of point-of-care biosensors that account for these discrepancies, in addition to being portable, highly selective, ultrasensitive, and capable of detecting extremely low concentrations of analytes from a single drop of blood. Specifically, nanomaterial-based electronic biosensors, such as BioFETs, are ideal candidates due to their inherent sensitivity, scalability, and ease-of-use. The goal of this project is to further develop and optimize a low-cost, printed,and handheld carbon nanotube-based electronic platform to detect ultralow concentrations of target biomarkers while ensuring device stability throughout testing.

#36 Caroline Esposito, Wellesley College

Title: Remeasuring the β-decay of 142-La

Abstract: The analysis of the β-decay of 142-La facilitates worldwide research as it has been and will continue to be useful for gamma-tagging with its intense, high-energy gammas. This allows for the decay of this isotope to be applied to studies of fresh-to-burnt fuel fission rate ratios. It also is a short-lived (t1/2 = 91.1min) fission product, so it can be used to determine reactor burn up. 142-La was previously studied in 1982 by E. Michelakakis et al. Using earlier findings as a benchmark, previous transitions were confirmed, uncertainties and intensities were updated, and an additional 35 transitions were identified. Also from this analysis, 8 energy levels were added and no evidence was found for levels at 2590, 3101, 3165, 4045. These findings have been compiled in an updated level scheme. The data used in this study is taken from an experiment at the CARIBU facility at Argonne National Laboratory where a pure beam of 142-Cs, is created from the fission of 252-Cf. This beam is then directed into the center of Gammasphere where it decays into 142-La and then 142-Ce. Gammasphere is a gamma ray spectrometer containing 110 high purity germanium (HPGe) detectors arranged in a 4π geometry. The decay is recorded, and data shared with the NNDC for subsequent analysis. These updated measurements and calculated uncertainties will have implications for future nuclear research and simulations.

#37 Ekaterina (Katya) Ulyanov, Williams College

Title: Optimization of a Large Mode Area Yb:fiber Chirped-Pulse Amplifier for Ultrafast Electron Diffraction Experiments

Abstract: Pump-probe ultrafast electron diffraction (UED) is a technique used to understand the structural properties of a material on an atomic scale. An optical pulse excites a thin material sample out of equilibrium, then an electron pulse interacts with the sample to generate a diffraction pattern. The time delay between the pump and probe pulses is adjusted and the process is repeated to understand the dynamic structural changes of a material following excitation.

This process requires an optical pulse with relatively high-energy (μJ) and high temporal resolution (fs), which our lab aims to achieve using a Yb:fiber chirped-pulse amplifier. Using frequency-resolved optical gating (FROG) as a diagnostic tool, we have identified several factors that may degrade the pulse quality of our laser, including intermodal dispersion and polarization mode dispersion, and discuss future steps to optimize the pulse output.