2K

Our Complex Universe: Planets, Stars, Black Holes, and Galaxies

Session Moderator: Jessica Werk, Astronomy
MGH 284
3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Observational Astronomy in Tacoma: Analyzing Jupiter's Rotation and the Brightness Profile of Saturn's Rings

Megan Longstaff, Senior, Applied Physics, Pacific Lutheran University
Justin deMattos, Senior, Physics, Pacific Lutheran University
NASA Space Grant Scholar
Mentor: Katrina Hay, Physics, Pacific Lutheran University
Mentor: Sean O'Neill, Physics, Pacific Lutheran University

Jupiter and Saturn are our solar system's largest gas giants with some of the most popular features of any known planet: Jupiter's Great Red Spot (GRS) and Saturn's rings. Over the summer of 2018, we analyzed these characteristics at Pacific Lutheran University's W. M. Keck Observatory. Closer to the Earth, Jupiter's atmosphere is subject to differential rotation in which the atmosphere of the planet rotate at different speeds. We use feature tracking and 2D to 3D mapping techniques to observationally determine the angular rotation of the GRS and compare it to the expected rotation of 11.5 km/s determined by the magnetosphere. Through our analysis we observe the movement of the GRS over multiple nights and determine the average speed to be around 10.97 km/s, a 4.60% difference from the expected value. Further beyond, Saturn's rings are composed of particles of ice and dust that are thought to be remnants of comets, asteroids, or moons that collided in orbit around the planet. Since these rings are not single structures, their particles feature non-uniform spacing. The light intensity of the rings increase as you approach the B ring from either direction (with the exceptions of the Cassini Division, Encke, and Keeler gaps). Our research focused on determining the spatial variation of these intensities as observed from our land-based observatory and comparing this data to Hubble Space Telescope data quantifying atmospheric scattering in Tacoma.

Atomic Absorption Line Diagnostics for the Physical Properties of Red Supergiants

Brooke Paula Dicenzo, Sophomore, Pre-Sciences
Mentor: Emily Levesque, Astronomy

Red supergiants (RSGs) are evolved massive stars that represent extremes, in both their physical sizes and their cool temperatures, of the massive star population. Effective temperature T_{eff} is the most critical physical property needed to place a RSG on the Hertzsprung-Russell Diagram, due to the stars' cool temperatures and resulting large bolometric corrections. Several recent papers have examined the potential utility of atomic line equivalent widths in cool supergiant spectra for determining $T_{eff}$and other physical properties and found strong correlations between Ti I and Fe I spectral features and T_{eff} in earlier-type cool supergiants (G and early K) but poor correlations in M-type stars, a spectral subtype that makes up a significant fraction of RSGs. We have extended this work by measuring the equivalent widths of Ti, Fe, and Ca lines in late K- and M-type RSGs in the Milky Way, Large Magellanic Cloud, and Small Magellanic Cloud, and compared these results to the predictions of the MARCS stellar atmosphere models. Our analyses show a poor correlation between T_{eff} and the Fe I and Ti I lines in our observations (at odds with strong correlations predicted by stellar atmosphere models), but do find statistically significant correlations between T_{eff} and the Ca II triplet (CaT) features of Milky Way RSGs, suggesting that this could be a potential diagnostic tool for determining T_{eff} in M type supergiants. We also examine correlations between these spectral features and other physical properties of RSGs (including metallicity, surface gravity, and bolometric magnitude), and consider the underlying physics driving the evolution of atomic line spectra in RSGs.

The Mass Transfer Geometry of V367 Cyg

Aislynn Wallach, Senior, Physics: Comprehensive Physics, Astronomy
NASA Space Grant Scholar, UW Honors Program
Mentor: Jamie Lomax, Physics, United States Naval Academy
Mentor: Emily Levesque, Astronomy

Companion-affected mass loss complicates our understanding of evolved stars; for example, theoretical models predict up to 70% of all main-sequence O stars interact with companions at some point during their lifetimes, but the details of mass loss and transfer in binary systems are poorly understood. V367 Cyg is an eclipsing, low-mass binary system with a complex geometry that offers a unique opportunity to better understand mass transfer processes; the primary star has overflowed its Roche lobe, resulting in an accretion disk that surrounds the secondary star. Using new spectropolarimetric data of V367 Cyg taken with the University of Wisconsin's Half-Wave Polarimeter (HPOL) at the Pine Bluff Observatory, I have resolved the behavior of the accretion disk by determining the position angle and intensity of the polarized light from the system as a function of orbital phase. Here, I will present an analysis of this data and discuss their implications for the mass-loss geometry of the system. By constraining the properties of this interacting binary, we can more precisely study the details of stellar mass transfer.

Source of Noise at Low Frequencies in LIGO OPLEV Measurements

Alexandra Glenn, Junior, Physics: Applied Physics
Mentor: Krishna Venkateswara, Physics, CENPA

The Laser Interferometer Gravitational-Wave Observatories uses michelson-type interferometers that have two, 4-kilometer-long arms with suspended test masses (mirrors) at the ends of the arms. The test masses reflect high-power lasers to be combined at the output port of the two arms and create an interference pattern, which is sensitive to gravitational waves passing through the interferometer. For a stable interference pattern, the test masses must be oriented precisely; the low frequency orienting of the test masses is done using optical levers. The optical levers consist of optics that launch light from a diode laser to reflect off the test mass and hit a quadrant photodiode which measures the position of the light spot. However the measurement of this position has elevated amounts of noise at low frequencies, limiting the angular motion accuracy. The reduction of this noise by a factor of 10-100, would allow for a more accurate orienting of the cavity holding the test mass. One possibility is that the noise is due to mode fluctuations in the fiber optics connected to the launching telescope. To isolate this noise I recreated parts of the LIGO OPLEV setup with a level of electronic position noise well below the order of LIGO's current OPLEV noise at 0.1 Hz (10-9 meter per square root hertz level). To achieve noise at this level I have made a new low noise pre-amplifier, improved the physical stability of the setup, and analyzed data to identify the noise sources.With this reduced noise setup we plan to search for the source of LIGO's OPLEV low frequency noise and ultimately reduce noise in gravitational wave detection at low frequencies. Reduced noise will lead to more GW detections and new astrophysics, which will allow us to 'hear' the universe in a unique way.

Ram Pressure Stripping and Tail Structures of Jellyfish Galaxies

Daniel Ryan Piacitelli, Sophomore, Pre-Sciences
Mentor: Iryna Butsky, Astronomy
Mentor: Thomas Quinn, Astronomy

Galaxy clusters are collections of galaxies that form the largest gravitationally bound structures in the universe. Because these galaxies are clustered together, they undergo a wide variety of processes and operate under a multitude of mechanics, differing from non-clustered galaxies, like our own Milky Way. One such example is ram pressure stripping. A galaxy that falls through the hot and dense Intracluster Medium (the space between clustered galaxies) is subject to a "wind" force that can strip it of its gas, usually producing a long gaseous tail emanating from the galaxies causing it to be dubbed a Jellyfish Galaxy. This phenomenon can be incredibly impactful as it can "quench" star formation in the galaxy or, in other words, it can cause the galaxy to "die." A galaxy is considered quenched when it has insufficient gas to form stars, and it is still not well understood why some galaxies become quenched and others do not. Learning more about this process can inform us on the life cycle of both the galaxies themselves and the cluster as a whole. We used the RomulusC simulation data, run on the NSF Blue Waters Supercomputer, which simulated a large galaxy cluster in high resolution. This simulation has allowed astronomers to study ram pressure stripping in a realistic setting for the first time. Comparing the results of this simulation to observations will supplement our understanding of galaxy clusters and the movement of matter in these colossal and highly dynamic systems.