UNIVERSITY *of* WASHINGTON

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Online Proceedings

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ASTRONOMY

Session Moderator: Suzanne Hawley, Astronomy
JHN 026
3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Observatory Cloud Monitoring System

Matt Armstrong, Senior, Astronomy, Physics: Comprehensive Physics
Mary Gates Scholar
Andrew James (Andrew) Wilkins, Senior, Astronomy, Physics: Applied Physics
Mentor: Joseph Huehnerhoff, Astronomy

The purpose of this research is to design, build, and deploy an all-sky cloud monitor instrument for Apache Point Observatory. This camera will be used to monitor the sky surrounding the telescope and provide sight down to the horizon via visual and numerical feedback. This research will create automatic image analysis software that will calculate sky brightness and uniformity, both of which can be used to constrain the level of atmospheric blockage. The cloud camera system will also have weather metrology feedback which can alert observers using the telescopes to current hazardous weather conditions. As a self-contained unit, this camera, and associated sensors, will require no actions by on-site or remote observers to function. An instrument with this mode of operation will allow for safe remote observing with minimal (to zero) engineering support. The end users of this instrument will be astronomers using the telescopes remotely. This will allow remote users to see the current sky conditions, which can have a great effect on their data.

Finding the Rotation-Activity Relation in a Spectroscopic Survey of Kepler M Dwarfs

Tessa D. (Tessa) Wilkinson, Senior, Astronomy, Physics: Comprehensive Physics
Mary Gates Scholar, UW Honors Program, Undergraduate Research Conference Travel Awardee
Mentor: Suzanne Hawley, Astronomy

Main sequence stars that are 20-50% the mass of the sun and have a cooler surface temperature of less than 4000 Kelvin making them appear red are classified as spectral type M. These low mass M dwarf stars are the most common type of star in the Galaxy and often exhibit strong magnetic fields and magnetic activity including chromospheric emission and flares. We are investigating how this activity is correlated with the rotation period and metallicity of the star. A dataset of a few thousand M dwarfs with measured rotational periods monitored by the Kepler spacecraft is now available to investigate these possible correlations. We obtained followup spectroscopic data from the ARC 3.5 meter telescope at Apache Point Observatory (APO), and report the spectral types and metallicities of nearly 100 Kepler field M dwarfs with measured rotational periods. Previous studies utilize the Kepler Input Catalog (KIC) for estimates of spectral type and temperature that are based on multi-band photometry. Our independent spectral measurements are crucial to improve on these parameters as the KIC measurements are known to be unreliable for low mass stars. Using reduced spectra from the APO/3.5m Dual Imaging Spectrograph (DIS) high resolution mode (R˜5000) we measured the magnetic activity through the chromospheric emission from the Hydrogen Balmer-alpha emission line. Metallicity measurements were obtained from DIS low resolution mode spectra (R˜1000) via comparison to M dwarf calibration stars with known metallicities. We present our results including the magnetic activity correlation with rotation and metallicity at different M subtypes, and discuss the implications of these data for low mass star evolution.

The Radioactive Habitable Zone

Benjamin Dean (Ben) Guyer, Senior, Physics: Comprehensive Physics, Astronomy
Mentor: Rory Barnes, Astronomy

With the first detection of an exoplanet in the 1990's, the goal of discovering life beyond our solar system became a real possibility. Since then, thousands of exoplanets have been discovered, many of which are Earth-sized and potentially habitable. The planned James Webb Space Telescope may be capable of taking spectra of the atmospheres of Earth like exoplanets to determine if life is present. However, technical constraints will limit the number of targets to only a few within its operational lifetime. Prioritizing targets based on their potential to support life is therefore essential. Here, we study one crucial, but often overlooked, factor in determining habitability – the internal thermal evolution of exoplanets. A planet that is too cold may lack geochemical cycles, such as the carbon cycle on Earth, that maintain a stable atmosphere. A planet that is too hot may be too volcanic to support life. In between lies a "habitable zone" of internal energy. To search for its limits, we use computer models to simulate the thermal evolution of planets as a function of two factors – abundance of radioactive elements, and initial internal temperature. Radioactive decay provides a modest but steady source of energy for planets, while events like the impact that formed our moon can deposit enormous amounts of energy but on a much shorter time scale. The results of our analysis suggest that a given planet's thermal evolution is far more sensitive to the abundance of radioactive elements than its initial temperature. For example, Earth without radioactivity would have become tectonically dormant in only 3 billion years. But with levels of radioactive isotopes like those in carbonaceous chrondrite meteorites, Earth could have experienced Io-like levels of volcanism for the first billion years.

Cataclysmic Pulses: Investigating Temperature Instability of Accreting White Dwarf Pulsators

Donald Francisco (Donald) Serna Grey, Senior, Astronomy, Physics: Comprehensive Physics
NASA Space Grant Scholar
Mentor: Paula Szkody, Astronomy

The compact core that remains after a star like our Sun dies is called a white dwarf. Some of these stars have close orbiting companion stars that they will accrete matter from constantly. This accretion eventually causes outburst events called dwarf novae. These binary star systems are known as cataclysmic variables. The six telescope observing targets for this project also undergo variable brightness pulsations due to temperature instabilities in the near pure hydrogen atmpspheres of these white dwarf stars. These variable brightness pulsations make these stars ZZ Ceti pulsators in addition to being cataclysmic variables. We present time series photometry in the optical range from cataclysmic variable white dwarf ZZ Ceti pulsators as part of an ongoing long term investigation of accretion dynamics and white dwarf internal structure. These light curves are used in comparison with UV light curves gathered from the Hubble Space Telescope to probe the temperature and pulsation properties of these targets. Previous observations suggest a temperature instability strip that is broader than current models predict. This investigation will empirically measure the instability strip as our pulsator telescope targets cool and restart regular pulsations after dwarf nova outburst events that were observed near the start of this project. Measurements of the time it takes the pulsations to reappear allows for an estimation of accreted mass and heating that occurred during the dwarf nova outburst. These measurements have confirmed the target SDSS0755+14 as a ZZ Ceti pulsator in the target pool and allow for tighter constraints and refined models of binary and accretion interactions of white dwarf systems, especially Type Ia supernova progenitor models.

Feasibility of Exomoon Detection and Spectral Recovery in the Presence of Exozodiacal Dust

Tiffany Channelle (Tiffany) Jansen, Senior, Astronomy, Physics: Comprehensive Physics
NASA Space Grant Scholar, Undergraduate Research Conference Travel Awardee, Washington Research Foundation Fellow
Mentor: Eric Agol, Astronomy

Although roughly two thousand exoplanets have been discovered and confirmed to date, exomoons have yet to be detected orbiting these planets. The detection of an exomoon would give insight into planetary formation and possibly increase the habitable real estate in a planetary system. Current telescopes are not capable of spatially resolving an exoplanet and its exomoon, or of separating the two blended spectra in a combined light measurement. However, previous work has shown that there is a wavelength dependent photometric centroid shift between a planet and its moon due to the weighted nature of the center of light (Agol et al. 2015). This spectroastrometric shift is highest in bands where the planet is dim and the moon is relatively bright, which can happen if it differs compositionally from its planet. As part of the "Finding the Needles in the Haystacks" project, we generated a realistic spatial / spectral model of an Earth-like exomoon orbiting a warm Jupiter in the habitable zone of a Sun-like star, including plausible exozodiacal dust structure. Preliminary results show that the presence of an Earth-like exomoon can produce centroid shifts greater than a milliarcsecond at some wavelengths, enabling the detection of the Earth-like exomoon even in the presence of dust. However, extracting the spectrum of the Earth-like exomoon has proved to be challenging, even when employing a simple telescope simulation devoid of coronagraphic effects, and further work will be needed to determine if it is possible even with 12-meter-class space telescopes.

Testing Our Models for the Stuff Between Galaxies

Bayu Jarod Wilson, Freshman, Physics: Comprehensive Physics
Adriana Cristina (Adriana) Gomez Buckley, Freshman, Physics: Comprehensive Physics
Mentor: Phoebe Upton Sanderbeck, Astronomy
Mentor: Matthew McQuinn, Astronomy

The models of the universe's diffuse configuration of hydrogen and helium atoms, known as the Intergalactic Medium (IGM), have become increasingly accurate in predicting the mechanics of the universe. Simulations of the IGM can provide a foundation for cosmology to be built upon. The purpose of our research is to test the accuracy and precision of our latest model of the IGM. Using data from the Very Large Telescope (VLT) in Chile, we analyzed quasar spectra for absorption lines at the Lyman-Alpha wavelength, creating phenomena called the Lyman-Alpha forest. We then processed this data incorporating scripts written in the programming language, Python, in order to compare the probability distribution function of the Lyman-Alpha absorption of the observed quasar spectra to the simulated quasar spectra. Interpreting our data we found that our simulations fell within one standard deviation of the observed data. Further analysis of our data showed that the simulations were more accurate for quasars at a lower redshift - those which were moving away from us at a slower rate - than quasars at a higher redshift - those moving away from us most rapidly. The largest contributors to error stem from the effects of other material in the IGM causing metal lines, our methods of metal line removal, and the limits of the size and quality of our observational sample. Metal lines skew our understanding of the Lyman-Alpha forest and a larger sample would decrease the variance among the samples. We plan on continuing research and improving the techniques of comparing the observations to models. An increased understanding of an effective model of the IGM can be used as a cosmological map of time to predict the origins of the universe as well as its future.