Session U – Astronomy

(Alphabetical)

Observational and Theoretical Astronomy: Which Way does the Causation Run?
Ishwari Bendre
Mentor: Jeffrey Lee Funk

Since the beginning of the 20th century, the field of professional astronomy has been split into observational and theoretical branches. Many would say that these branches complement each other perfectly, with observations confirming postulated theories and vice-a-versa; in other words, causation runs both ways in astronomy. The purpose of this project, however, was to research and analyze the various ways in which observational astronomy has influenced theoretical astronomy and show that causation running that way is more powerful than is generally acknowledged. While collecting data, it was found that, in most cases, a new/unexplained phenomena was seen in the sky and several theories were put forth in order to explain it. There were also cases found where limitations in observation tools (especially telescopes) lead to theoretical suggestions for improvement. Besides these, the paper also talks about observations opening up new fields of study not only in theoretical astronomy, but in physics as well. It should be noted that this study does not claim to be comprehensive, and there is scope for further research in the way of finding more evidence supporting each group and possibly finding more ways in which observations influence theory in astronomy.

Developing a Systematic Detrending Algorithm for Photometric Time Series Data
Giri Gopalan
Mentor: Peter Plavchan

We apply an implementation of the Trend Filtering Algorithm (TFA) from Kovacs, et al. (2005) to the 2MASS calibration catalog and selected Palomar Transit Factory photometric time series data. We note that while TFA is successful at reducing the overall dispersion of light curves, it filters intrinsic variables and increases “instantaneous” dispersion, an undesired consequence. To rectify these issues, we modify TFA by including measurement uncertainties in its computation and optimizing the selection of a template set.

Finding the Initial Mass Function for the G48.9-0.3 Component of the Cluster W51
Jennifer J. Greco
Mentor: Jessica Lu

Stellar clusters with masses greater than 10,000 solar masses are born in giant molecular clouds and physically and chemically interact with their surroundings to a much greater extent than smaller clusters. One of the key properties in determining how these clusters form and impact their environments is their initial mass function - the number of stars in the cluster born at a given mass. Initial mass functions have been constructed for many low mass clusters, with masses less than 2000 solar masses, such as Orion and Taurus. However, very few well-measured initial mass functions exist for high mass clusters. Our work examines a high mass cluster, G48.9-0.3 with mass, $M = 10^4\ M_{sun}$ in the W51 giant molecular cloud. We extracted infrared photometry at the J, H, and K wavebands for the stars in the cluster from UKIDSS, the UKIRT (United Kingdom InfaRed Telescope) Infared Deep Sky Survey of the galactic plane. These images are deeper and have higher spatial resolution than any prior images taken of this cluster. Using the infrared colors and luminosities of the stars in the cluster, we measured the cluster’s mass function. Since G48.9-0.3 is a very young cluster, as indicated by its still being embedded in its parent cloud, its current mass function is the same as its initial mass function. We then compared it to the initial mass functions of other smaller clusters to determine how star formation for high mass and low mass clusters are different.

On the Detectability of a Dark Matter Feature in the Intensity Energy Spectrum and the Anisotropy Energy Spectrum of the Gamma Ray Background
Brandon Hensley
Mentors: Tony Readhead and Vasiliki Pavlidou

Recent observations of many diverse astrophysical phenomena all suggest a substantial non-luminous and non-baryonic component to the total matter in the universe. The properties of this “dark matter” can be explained by several particle models, with some of the most prominent requiring dark matter particles to self-annihilate and produce gamma-rays as a byproduct. Annihilating dark matter in the galactic halo would contribute to the nearly isotropic gamma-ray background that is composed primarily of extragalactic sources such as blazars. The dark matter contribution to this background would be anisotropic since it depends on the distribution of dark matter in the galaxy and would therefore result in a modulation in the angular power spectrum of the emission. Given an observation of that modulation, we demonstrate that it is often possible to reconstruct the dark matter intensity as a function of energy. We further determine the detectability of such a signal based upon both reasonable and pessimistic models of emission from dark matter and blazars that are in accord with recent observations made by the Fermi Space Telescope. Even if no signal is observed, we show that strong constraints can still be placed on models of both dark matter and blazars.

Back End Electronics for the OVRO 40-Meter Telescope
Kirit S. Karkare
Mentor: Anthony C. S. Readhead

Blazars are active galactic nuclei – small, extremely luminous objects at the centers of galaxies powered by material accreting around a supermassive black hole – which emit relativistic jets of highly energetic plasma along our line of sight. There is currently no accepted model for jet composition, acceleration, and confinement; observations at different wavelengths will help us understand these emission mechanisms. The 40-Meter Telescope at the Owens Valley Radio Observatory has been monitoring 1200 blazars every two days since 2007, and the variability in radio light curves will be correlated to gamma-ray data from the Fermi Gamma-ray Space Telescope. A new correlation receiver for the telescope is in development, which will offer polarization measurements and increased sensitivity. We present a field-programmable gate array (FPGA)-based design of the digital back end electronics for the receiver. Using FPGA devices developed by the Center for Astronomy Signal Processing and Electronics Research group at UC Berkeley, the back end will digitize the signal from the front end, extract polarization information, and output the Stokes parameters and signal power to an Ethernet connection.

Analysis of the Ultraviolet Spectra of Galaxies at Redshift~4
Gongjie Li
Mentors: Nick Scoville and Peter Capak

Understanding the properties of galaxies at high redshift~4 will provide information on the environment of universe at the age of a few billions years, which is only a 10% of the age it is now. In this project, I analyze the ultraviolet spectra of galaxies at around redshift 4, obtained from the Keck observing program "Comprehensive Study of High Redshift Galaxies in the COSMOS Field." I get model spectra at different ages and with various metallicities from program Starburst99. By comparing the models and the observational spectra, I deduce the extinction curve and the intrinsic spectra of the galaxies. With the intrinsic spectra, I derive the masses, the ages, and the star formation rates of the galaxies. From viewing these models spectra, I have developed a logical technique for the analysis of the UV spectrum. Specifically, the existence of the CIV absorption line indicates a star formation within 10 million years, and an intrinsic slope of the spectrum. Also, there is no significant change in the UV portion of the spectra at different ages, thus the age of a star population within a galaxy can be determined from the ratio of the UV portion to the optical portion.

Mergers of Black Hole Binary Systems: a Perturbative Approach
Guglielmo Lockhart
Mentors: Sterl Phinney and Michael Kesden

Binary systems consisting of a small black hole in a circular orbit around a much larger one dissipate energy and angular momentum into gravitational waves, eventually coalescing to form a single black hole. Understanding gravitational-wave emission by binary systems throughout the merger is a problem of great importance for gravitational-wave detection. We employed frequency-domain black-hole perturbation theory to analyze the evolution of binary systems for a range of black-hole spins and mass ratios, following the trajectory of the smaller black hole down to the vicinity of the event horizon of the larger black hole. This computation allowed us to determine the maximal spin that can be achieved by a black hole through accretion of test particles. We also extrapolated the results of our analysis to the case of equal-mass black holes to predict the spin and angular momentum of the final black hole, finding for the moment an excellent agreement with the results of numerical-relativity simulations.

Digging into Leftover Debris from Galaxy Collisions
Aliza Malz
Mentor: Kartik Sheth

Galactic interactions shape the morphology of galaxies, but the exact proportion of galaxies undergoing interaction in the nearby universe remains unknown. A very sensitive measure of the degree to which a galaxy is undergoing an interaction is the extremely faint stellar debris that can be traced in the near-infrared only with a space based telescope like Spitzer. Visual inspection of near-infrared debris disks may be a robust primary method for detecting galaxy interactions, as no previously identified interacting galaxy lacks significant asymmetries in this debris disk when observed. We investigate the outer regions of 597 galaxies that are a part of the Spitzer Survey of Stellar Structure in Nearby Galaxies (S^4G) and have been observed with Spitzer's IRAC camera, determining for the first time how many nearby galaxies are interacting. Further analysis of the S^4G data set includes making estimates of the mass in the disk, neglected in shorter-wavelength evaluations, and advanced morphology analysis, including ellipse fitting with IRAF and galaxy fitting with GALFIT.

Evolution of the Spheroidal Luminosity Function in the GOODS Survey
Michael V. Maseda
Mentors: Richard S. Ellis and Andrew J. Benson

We apply the GALACTICA (GALaxy Automated ComponenT Image Construction Algorithm) code of Benson et al. 2002 to the I<22.5 GOODS-N/S catalog, with a redshift cut of 0.3<z<0.5, to decompose each galaxy into a bulge and disk (spheroidal) component. By decomposing the galaxies into separate components, we are able to determine the ratio of the bulge luminosity to the total luminosity of the galaxy. A careful study of galaxies in this manner allows us to calculate the bulge luminosity function for the field. Since we perform our study over a large redshift range, we effectively calculate the bulge luminosity function at different periods in time. Thus, we trace the history of the bulge luminosity function in Hubble's Z-band. Our bulge luminosity function further constrains the spheroidal mass function and hence allows us to draw conclusions about the formation of spheroidal systems and their central Supermassive Black Holes (SMBH's).

Near-Infrared Studies of Galactic Globular Clusters and Dwarf Spheroidal Galaxies
Liuyi Pei
Mentor: Judy Cohen

The study of Galactic globular clusters requires us to know certain basic properties of stars in the clusters. One such property is the effective temperature of these stars. By putting wide field near-IR images taken at the Palomar telescope through a series of image reduction procedures, I produce first accurate photometry for a large number of member stars, then color-magnitude diagrams for the globular clusters M13 and M92. These data will then be used for a search of rare types of stars in these clusters.