ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
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(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Robert Davidson, *Developing a Hydrodynamics Code for Modeling Gravitational Instabilities in Protoplanetary Disks,* (J. Bjorkman)

Stars form from very cold, gaseous clouds that collapse under their own self-gravity, but the clouds from which they form also create another interesting astronomical feature: protoplanetary disks. Researchers are divided as to the mechanism for planet formation, but regardless of the method, the disk cooling time is an important factor. Using a computer program, my goal for this project was to develop a subroutine that would calculate the geometrical thickness of a disk of material using an input array of temperatures versus surface density. We found that the subroutine was in agreement with analytical calculations for simple cases such as isothermal disks. The computational model was also in close agreement for more complex cases like a disk with changing temperature. Using this subroutine with real temperatures and surface densities will allow for a working computer model to be tested for success or failure. Regardless of the outcome, we are confident that such a model will only aid in the development of more accurate and realistic planet formation simulations in future research.

Amber Ferguson, *Finding the radial velocity of the double-lined spectroscopic binary, beta Trianguli, using Cross-Correlation,* (N. Morrison)

Cross-correlation is a task in the program IRAF (Image Reduction and Analysis Facility). Although it is not a new method for finding velocities of astronomical objects; it hasn't yet been used in determining the radial velocities of the double-lined spectroscopic binary, beta Trianguli. I used cross-correlation to solve for the radial velocities of the primary component of the binary. When the secondary component was present I had to use a task called deblend to find its radial velocity. This star has been studied before, but we utilized this new approach to try and obtain more accurate results.

Shellie L. Huether, *Periodic Variations in the Emission Lines of Zeta Tau,* (K. Bjorkman)

The emission lines of Be stars are usually double peaked due to the rotation of the circumstellar disk. Zeta Tauri exhibits this feature in both the Hα and the Fe II, with the V/R ratio of the peaks varying periodically due to different density regions in the disk. At certain times the Hα emission becomes triple peaked, a phenomenon yet to be completely explained. A spiral shaped disk has been proposed as a model that can explain the triple peak in the Hα emission. To attain a better picture of the disk's structure, we investigate the behavior of the Hα, Fe II, and the He I lines of Zeta Tau. The observations span from 1997 to 2006, and were taken at the Ritter Observatory at the University of Toledo.

Kristen Jones, *High Mass Star Formation in NGC 6334 I and I(N),* (S. T. Megeath)

The presence of massive stars drives the evolution of molecular clouds. Despite their importance, however, little is known as to how high mass stars form. We seek to investigate low and high mass protostars within the ideal star formation area that is NGC 6334. Observations from the 8-m Gemini South telescope at 1.2 μm, 1.6 μm, and 2.2 μm and the 85-cm Spitzer Space telescope at 3.6 μm, 4.5 μm, 5.8 μm, and 8.0 μm are reduced and analyzed for low mass star formation as a function of distance from high mass protostars.

Daniel Moomey, *The Abundance of Cl I and Cl II in Interstellar Gas Clouds*, (S. Federman)

Observations from the Copernicus satellite were used to determine the abundances of Cl I and Cl II along 22 sight lines. Observations at lambda = 1071, 1088, 1097, 1347 Å were analyzed to measure the equivalent width of the lines along each direction. A computer simulation was run to determine the chlorine abundances from each absorption line. The lines of the same species were then weighted to create an average as the final column density for that species toward that line of sight. This has successfully been done for 19 of the 22 stars so far. The Cl abundances will be compared with H abundances for studies on its chemistry and the amount of chlorine tied to solid interstellar grains.

Paul Sell, *Visible Wavelength Emission from High Galactic Latitude Clouds*, (A. Witt & S. Federman)

The study of high galactic latitude interstellar clouds is still in its infancy. Thus far, mainly radio and far-infrared observations have been used to map these clouds, while, at optical wavelengths, they have largely remained unexplored. This is primarily the result of the low optical surface brightness of these clouds as their emissions are at most about 5-10% above the background light of the night sky at even the darkest observing sites. Therefore, mapping these clouds at optical wavelengths requires weeks of observing time, far more than would normally be granted at a large telescope capable of adequately imaging these clouds. As a result, we are using small but fast amateur-sized telescopes that can be used exclusively for our purposes and that have much larger fields-of-view than larger telescopes. We rely on the optical principle that detection of extended sources of diffuse light does not depend on the aperture of the telescope but is exclusively dependent on the focal ratio of the telescope, independent of its aperture. We carried out optical broadband photometry on a set of three high galactic latitude clouds with a f/5.0, 100 mm refractor to search for Extended Red Emission (ERE), Hα emission, and to image the large-scale structure of these clouds. We confirm the detection of the ERE in these clouds and provide evidence of a shifting peak and varying intensity of this emission from cloud to cloud. Our observations are in very good agreement with the long-slit spectroscopic observations made with a much larger telescope of one of these three clouds at optical wavelengths as well as with the results of a large-scale search for ERE based on observations obtained with Pioneer 10 and 11.

Atomic/Molecular/Optical Physics

Christopher Galyean, "*Electron Optics Simulation for the Design of a Secondary Electron Energy Analyzer*," (T. Kvale)

The work performed this summer focused on the creation of an electrostatic lens for use with a hemispherical energy analyzer. The lens is to be used to focus electrons emitted from a solid target due to collisions from an energetic (5 - 50 keV) proton beam upon the target surface. Modeling of the electrostatic lens was done using Simion 7.0. For simplicity, the sheath of the electrostatic lens was considered to be at ground voltage. This can be corrected when the mean voltage of the hemispheres of the energy analyzer is determined by adding the mean voltage to the voltages of the electrodes. It should also be noted that, when considering a grounded sheath, it is possible to scale the initial electron energy to any value as long as the same ratio is kept with the voltages on the electrodes. The final design of the electrostatic lens is a two electrode step-down configuration. The sheath of the lens will extend past the faceplate of the energy analyzer and end exactly at the depth of the hemispheres to ensure that no stray electric field may interfere with the electron trajectory. Through the modeling process, a difference of only 0.01 mm between the focal point of the emitted electrons and the hemisphere entrance was achieved. Also, the diameter of the disk of least confusion was found to be 0.025 mm, and the fill ratio of the electron trajectories compared to the

difference in hemisphere radii was found to be 0.296. These values suggest that the design for the lens is plausible for construction and use for the hemispherical energy analyzer.

Biological, Health, and Medical Physics

Marian Axente, *Dosimetric Analysis of Absorbed Dose from Scattered Radiation in IMRT Delivery Using Tungsten Leafs as Compared to Compensating Filters,* (E. I. Parsai)

Inverse planning with Intensity Modulation Radiation Therapy (IMRT) using multi leaf collimation system has revolutionized the radiation delivery in terms of delivering dose to target organ while sparing the surrounding normal tissues. However, very large monitor units (MUs) and small fields has always been a concern for physicists in terms scattered dose to shallow regions in the field, and quality of beam delivered specially in out-of-field areas. This project involved a comparison between two methods of delivering intensity-modulated beams – compensator (milled brass beam filters) and conventional multi-leaf collimators (tungsten leaves), with a special attention to out-of-field dose analysis. No base line methodology for this study is described in the recent research literature, so several methods were used. Acquired data showed that in-target conformity (volumetric), and dose uniformity (planar) in central-axis and off-axis at different depths, compensators do a similar if not better job at delivering IMRT plans. Regarding dose from scattered radiation, initial measurements reveals that compensators do deliver less to the area surrounding the target volume.

Brian J. Bismack, *Brain Perfusion Study*, (M. Dennis)

The cause of migraines has been somewhat of an enigma that this study hopes to shed some light on. The study involved a comparison of vascular reserve and blood flow through tissues of the brain between different groups of people. Of particular interest is of course the comparison between people with migraines and people without migraines, but the study also involved a group of people with migraines who also had a skin condition called livedo reticularis. The overall goal of the study is to see how migraines and livedo reticularis affect a blood flow to the brain and vascular reserve. Direct data collection involved a series of Echo Planar Images (EPI) from a MRI system while a contrast agent was injected into the blood stream and entered the brain. This gave data on how blood flows through the brain. Two data runs were performed on each subject, the second data run involved a vasodilator called Diamox. This gave data on the subject's physical capacity to increase blood flow.

Condensed Matter Physics

William Booth, *Solar Cells and the Design of A Substrate Heater,* (S. Marsillac)

Solar cells are slowly becoming an important part of our quest for alternative sources of energy. More productive and more efficient processes need to be designed in order to create better power efficiencies for the solar cells while keeping them cheap. Using the method of vacuum evaporation one uses a substrate heater, which the elements are deposited on, in order to change the properties of the solar cell. These properties include the mobility of the carriers, the morphology, and the composition of the cell. Much of the technical information about the vacuum evaporation system was taken from Vacuum Technology Products by the Kurt J. Lesker Company. Much of the information about the various solar cell materials was taken from Fundamentals of Photovoltaic Materials by the National Solar Power Research Institute. Most of the basic cell theory was taken from Solar Electric Systems by George Warfield.

Anna Dupay, *Micro-Magnetic Simulations on Cobalt Nanostructures,* (R. A. Lukaszew)

It remains a challenge to model magnetization dynamics at the nano-scale. The purpose of this research project is to simulate arrays of nanomagnets that can be fabricated using a novel nano-patterning method based on the use of micro-spheres. By using Object-Oriented Micro-Magnetic Framework (OOMMF) to simulate the magnetic behavior of arrays of nanomagnets produced with this method we can predict how the magnets will behave in real life and also predict how this nano-patterning process can be used for research in nano-scale magnetism, for data storage, and other industrial and scientific applications. Preliminary work indicated that some of the methodology and parameters used ought to be adjusted to produce clearer and more consistent results.

Mary Lin, *Plasma Spectroscopy of rf sputtering for CdS,* (A. Compaan)

During the development of the thin film used in photovoltaic cells, the quality and efficiency of the solar cells can often be determined using a method known as spectroscopy, which can aid in identifying the elements present during the sputtering process of making the thin films. In the process of solar cell sputtering, the atoms of the elements present gain energy and briefly become excited, giving off light in a spectrum of wavelengths characteristic to that element. Using spectroscopy, the individual spectra of light produced by different elements can be analyzed and their peaks identified, giving us valuable insight about the types of elements present during the sputtering process. While ideally only the target elements and the noble gas should be present during sputtering, it is possible for even minor contaminants and impurities to affect the ultimate efficiency of the solar cell being produced.

In this experiment, the spectrometer was used to analyze the sputtering of cadmium sulfide onto a glass substrate in the AJA sputtering chamber, using argon as the sputtering gas. The expected impurities that we were looking for in the spectroscopic data were calcium, copper, magnesium, iron, and chromium. After calibrating the spectrometer by accounting for the shift in wavelength it produced during data collection according to the pixel number assigned to each peak, however, the majority of the peaks were identified as argon. Many of the major non-argon peaks were then identified as produced by cadmium and sulfur, though the data suggests the presence of copper during the sputtering as well.