ABSTRACTS OF REU FINAL REPORTS

The University of Toledo, Department of Physics & Astronomy
SUMMER 2010
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Rachel L. Arnold, *Extragalactic Globular Clusters:A Study Of Structure Through Simulation*, (Rupali Chandar)

Star clusters have three basic properties: age, mass, and size. There have been manystudies of the ages and masses of star clusters in nearby galaxies, but much less time has been devoted to understanding the structures of these clusters, despite the fact that stellar density plays a large role in their evolution. Even with high resolution images taken with the Hubble Space Telescope, the profiles measured for star clusters can have a number of biases, particularly for young clusters which form in crowded regions of galaxies. Weare using MASSCLEAN (Massive Cluster Evolution and Analysis package), a new,publicly available stellar cluster simulation program, to quantify biases in size measurements of extragalactic star clusters at different distances. We also reproduce wellknown Galactic clusters, e.g. the Orion OB1 cluster, and simulate what these would look like in more distant galaxies.

Timothy Carleton, *The Study of PAH Emission in Post-Starburst Galaxies and The Discovery of C60 in NGC 7023 and NGC 2023*, (J.D. Smith)

Emission from PAHs represent important features in the infrared spectra of galaxies. I am studying the PAH emission in post-starburst galaxies. To do this I construct and analyze spectral cubes of 15 post starburst galaxies. This can not only tell us about the role PAHs play in galaxy evolution, but also the properties of post-starburst galaxies.C60 is a spherical molecule of pure carbon that has been theorized to exist in space, but has yet to be detected. We detected C60 in thereection nebula NGC 7023 and NGC 2023.

Zachary Draper, *Modeling and Observations of Classical Be Stars π Aquari and 60 Cygnii*, (Karen Bjorkman)

Classical “Be” stars are massive main sequence stars that are rapidly rotating and have a circumstellar disk. The central question into their research is too answer how they form and control their circumstellar disk. To this end, studying their disks during phases of growth and loss and then modeling their behavior is crucial to understanding their underlying mechanism controlling the disk. Two stars of focus are π Aquari and 60 Cygnii both of which experienced a disk loss phase in the 1990's and are in the process of regrowing. Presented here is the efforts to reduce π Aquari H-alpha spectra from the Ritter observatory from 1996 to 2007 during a disk growth phase, model polarization angle deviations from the mean, and model the polarization across the Balmer Jump vs continuum Vband polarization of both stars using published previously in Wisniewski et al. 2010.

Matthew. Korpela, *The Delta Scorpii Be Binary. The Disk Development and Periastron 2011*. (Karen Bjorkman)

Delta Scorpii is a bright (V=2.3 mag) binary system with a B0-type primary and supposedly a B-type secondary at an eccentric orbit (e=0.94). A brightening detected in the summer of 2000 marked the beginning of a circumstellar disk formation around the primary component. It occurred a few months before the periastron which was detected through a strong radial velocity change in September

2000. We present a history of the disk development and discuss possible explanations for the observed variations of the optical and near-infrared brightness and emission line profiles. The next periastron is predicted to occur in early July 2011. We emphasize the importance of frequent observations of Delta Scorpii with various techniques in 2011, predict some phenomena that may occur near periastron, and suggest observing strategies.

Rebecca Kutsko, *Analyzing the Hydrogen Lines of Protostars in the Orion Molecular Cloud using Near-Infrared Spectra*,(Will Fischer and Tom Megeath)

The study of the accretion luminosities of protostars is an essential step to understanding their evolution. These young stellar objects (YSOs) are completely surrounded by envelopes of dust and gas, so they are unable to be seen in any optical wavelength. Instead, infrared wavelengths are used to observe past the dust and study the objects within. By measuring the spectra of protostars (class I YSOs) within the Orion Molecular Clouds, we were able to obtain their accretion luminosities and compare them to a study of class II YSOs, which are more evolved objects whose envelopes have dispersed. With 1-2.4 micron spectra obtained using the SpeX instrument at NASA's Infrared Telescope Facility, we analyzed 8 class I protostars and 4 class II sources. We measured the equivalent widths of the atomic hydrogen emission lines Paβ (1.28 μm) and Brγ (2.17 μm) and wrote an IDL program to convert the equivalent widths to line luminosities and then to accretion luminosities using the relationships found by Muzerolle et al. (1998) for class II YSOs in Taurus. Our results suggest that the younger protostars have a higher median accretion luminosity than the class II YSOs by almost a factor of 50. We thus conclude that it is possible to estimate protostellar accretion luminosities using infrared hydrogen emission lines; this is the most direct method available to study the disk-to-star accretion flow in embedded protostars.

Marina Kounkel, *Search for Binary Protostars in the Orion Molecular Clouds*, (S. Thomas Megeath)

The Orion molecular clouds contain the largest sample of protostars within 500 pc of the Sun. As part of a coordinated, multi-observatory program to study protostars in Orion, we observed 36 fields around protostars using IRTF with NSFCAM2 at L' band wavelength. In addition to mapping the scattered light from the individual protostars (the primary goal of the program), these data allow us to detect companions at separations as small as 300 AU at the distance of Orion. We present a search for close companions to the protostars using the IRTF data. By combining the IRTF imaging with a Spitzer space telescope survey of the Orion clouds, and NICMOS imaging we determine the density of candidate YSOs as a function of distance from each of the targeted protostars. With this analysis, we find a clear enhancement in the density of sources near the protostars, indicating that the apparent nearby companions are not due to chance alignments. We compare the incidence of multiplicity with that found in other star forming regions and in the field. This project is the continuation of previous summer research using NICMOS imaging used for finding binary protostars

Tiffany D. Pewett,*Theta Corona Borealis: From Be star to B star and Back*,(Karen Bjorkman)

B-emission class stars are stars that hold disks around them resulting in hydrogen and helium emission lines in their spectra. Little is known about how and why these disks form. One known contributing factor is the fact that they are rapidly rotating. There have to be other factors though, considering not all rapidly rotating stars have disks and the disks tend to disappear and reform randomly. Theta Corona Borealis is such a star, however it has been highly understudied. It is believed that its disk faded away in 1970 when the star's apparent magnitude decreased by about fifty percent of its normal brightness. Then, in 2006, the disk started reforming slowly, then began fading again. My goal was to analyze the available data collected at Ritter Observatory to determine when, and possibly why, the disk disappeared and is now trying to reform. No pattern has yet been discovered but I will

continue my research beyond the program in the hopes of better understanding the processes behind the formation of Be stars.

Todd Skinner,*Modeling Microturbulence in Stellar Atmospheres*,(Lawrence Anderson-Huang)

We can develop our understanding of microturbulence in hot stellar atmospheres by modeling the radiation in a section of the stellar atmosphere. The code used to run this simulation, however, is complex and needs to do many computations over a large three-dimensional grid over multiple iterations. This code needs to be parallelized in order to efficiently study the microturbulence. The aim of this project was to attempt a parallelization of a subroutine of the code that solves for the radiative transfer across a three-dimensional grid and improve upon the numerical methods used in calculating the radiation field.

Corbin Taylor, *Lithium In Ic 443: A Study In Light Element Synthesis*,(Steve Federman)

Cosmic ray and neutrino-induced spallation processes are thought to be production pathways for the light element Li, making supernova remnants possible sites for the element's synthesis. Observations toward the OB stars HD 43582, HD 254477, HD 254577, and HD 254755 in the vicinity of the supernova remnant IC 443 were made at the 9.2 m Hobby-Eberly Telescope ($R\sim10^5$). We analyzed the Li I doublet at 6707 Å to obtain the $^7Li/^6Li$ abundance ratio for two of these sight lines, as well as absorption lines for K I, Ca I, CH, and CH^+ to aid in the line fitting. The goal of this research is to further our knowledge about the synthesis of Li and the light elements in general.

Atomic/Molecular/Optical Physics

Deven Kelling, *Current use of The Toledo Heavy Ion Accelerator*, (Thomas Kvale/Richard Irving)

The Toledo Heavy Ion Accelerator, THIA, has issues with beam instability. The research used for this paper studied the Electrostatic deflection chamber, and it's inherent sources of beam instability. It was found that damage to the deflection plates within the chamber was a prime factor in the resulting beam instability the is seen at the end of the line. This damage is the result of impact ionization of the beam incident on residual gas particles in the vacuum.

Biological, Health, and Medical Physics

Caitlin Dunn, *Improving the Model used for Intensity Modulated Radiation Therapy,* **(**Dave Pearson**)**

Radiation therapy is a common treatment for cancer despite the danger of radiation to noncancerous cells. The scientific community has been continuously working on a process to make radiation therapy treatments more successful. The rate of success is correlated with how much healthy tissue is spared while still irradiating the entire target. Recently intensity modulated radiation therapy (IMRT) has become the best way to administer complicated plans to patients. IMRT has many advantages, but one major barrier is that the IMRT planning process is too complicated to compute manually. This barrier can be overcome with a good modeling program. Pinnacle is the program currently used at the University of Toledo Health and Science Campus and it performs well under most circumstances. However it has been noticed that when doing quality analysis (QA) for IMRT plans that use many small heavily blocked fields the error is higher. By using different ion chambers to obtain more consistent data we were able to create a new model that was more accurate.

Mandy Kilbourn, *VBM: Voxel based morphometry for the study of brain differences between lower-limb amputees and control subjects*, (Micheal Dennis)

Voxel based morphometry, or VBM, is a technique used to compare brains on a voxel-by-voxel basis. VBM uses MR images that have been spatially normalized, which can then be compared to find differences between gray matter concentration between two groups of subjects. This study consisted of eleven male lower-limb amputees and seven male control subjects. The VBM analysis was carried out in MATLAB 7.10.0 using SPM8, a program from the Functional Imaging Laboratory (FIL) in The Wellcome Trust Centre for NeuroImaging, in the Institute of Neurology at University College London (UCL), UK. Differences were reported for $p=0.005$, with $2.58<Z<3.83$. Using these parameters, statistical parametric mapping (SPM) led to the identification of 15 areas of average lower concentration and 13 areas of average higher concentration in the amputee brains. In the future, the preliminary results from this study will be compared to the results of the Freesurfer analysis for cortical thickness, as well as to results from longitudinal studies from individual subjects.

Condensed Matter Physics

Julia Deitz, *Exploring Possibilities of Cadmium Selenide Nanocrystal Solar Cells,*(Randall Ellingson)

With limited past success with Cadmium Selenide nanocrystals for solar cells, it was hoped that more efficient versions could be made. In attempts to make the solar cells, many problems were faced with the CdSe nanocrystals attaching to the substrate. This was caused from the unknown surface chemistry of the nanocrystals that were worked with. Many techniques were used in attempts to understand the surface chemistry and successfully attach the nanocrystals to a substrate, but the surface chemistry remains unresolved.

Katie Hoepfl, *Comparison of Solar and Wind Power Output and a look at Real-Time Pricing, (*Alvin Compaan, Andrew Solocha, Kristopher Weiland)

This paper presents a method that can be used to determine the least volatile power output of a wind and solar hybrid energy system. Hourly data for a wind and PV system in Toledo, OH is used to show that a combination of both types of sustainable energy produces a much more stable power output and would be more easily tied to the grid than either individually. This method could be used to determine the ideal ratio in any part of the country and should be used to convince energy companies to bring more renewable online. This paper also looks at real-time market pricing and how each system (solar, wind, and hybrid) correlates with the 2009 hourly pricing.

Andrew Moore, *Texture Characteristics of Aluminum Back Reflectors,* (Qi Hua Fan, Dr. Bill Ingler)

This report seeks to characterize the texture of thin aluminum films for solar cell application. Aluminum was deposited on glass slides, controlling various deposition parameters such as temperature, power, power type, pressure, and time. The samples were scanned by an atomic force microscope (AFM). The AFM produces a 3-dimensional image of the surface in the nanoscale. A program was developed to analyze the AFM data and calculate a texture angle and height for each surface peak. The average angle and height for a given sample is its characteristic texture. Systematic tests in controlling the texture by altering deposition parameters were also analyzed.

Nathan Reaver, *Effects of Back Contact Materials on Substrate Configuration CdTe Solar Cells,* (Kristopher Wieland, Alvin. Compaan)

Substrate configuration CdTe photovoltaics has the potential to provide both a reduction in the production costs and improved power to mass ratio. In this study the effect of copper placement in the cells, sequence of CdCl2 treatment, and the effect of back contact material on cell performance was examined. Cells were deposited on a Mo coated conductive substrate, on stainless steel or on TCO

coated glass, using RF magnetron sputtering. Three different back contacts were used, copper-gold as used in superstrate configuration cells, Sb2Te3, and ZnTe:N. Cells were measured using a solar simulator at one sun to obtain current density vs. voltage curves and cell efficiencies. The structure that gave the best performance was stainless steel/Mo/Sb2Te3/CdTe/CdS/ZnO/ZnO:Al, with the best cell having an efficiency of 5.34%.