ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2012 (Faculty Mentor on parenthesis)

Astrophysics

Steven Cloutier, "*An effort towards completing a solar neighborhood survey of Brown Dwarfs*," (Michael Cushing)

The opportunity to study ultra-cool atmospheres in the universe has been largely nonexistent for the better part of the last century. With the advent of surveys in the near infrared, our ability to identify and study these objects, primarily Brown Dwarfs, has materialized. One of the outstanding questions is how these objects form. To this end the spatial density of brown dwarfs is being determined within 20 pc of our sun. Using observational data from the Folded-port InfraRed Echellette (FIRE), the spectra of six brown dwarf candidates was analyzed. As a result we have added six new brown dwarfs to the census of brown dwarfs known to be within this region, along with respective distance, temperature, and gravity estimates, further refining our spatial density estimates.

Matthew Kurth, "*Extended Red Emission in Pleiades Reflection Nebula*," (Adolf Witt)

The Extended Red Emission (ERE), a dust-related interstellar photoluminescence phenomenon, is observed in many star forming regions, but is often overshadowed by multiple other processes occurring in those environments. In an interstellar dust cloud, the ERE is simpler to identify and work with. To observe the ERE in an interstellar dust cloud, the dust in the cloud must be in the vicinity of stars that illuminate it. This is why we are observing the Pleiades star cluster and the nebula that surrounds it. In particular, we initially placed special focus on the Merope nebula, which is the nebular region south of Merope. This system containing stars and interstellar dust is known as a reflection nebula, and in this case is the result of an accidental encounter of the Pleiades star cluster with an interstellar cloud.

Meredith McLinn, "*Graphic Visualization of 3D Radiation Hydrodynamics*," (Lawrence Anderson-Huang)

Antonio Porras, "*Cosmic Rays in Space*," (Steven Federman)

To further understand the origin of cosmic rays, we analyze CH and CH^+ found in a variety of diffuse molecular clouds in order to find OH^+ in this environment. OH^+ is produced by cosmic ray ionization. Our goal is to extract the cosmic ray ionization rate in clouds from the OH^+ absorption lines. We do this by first measuring clouds Doppler effect. After finding each velocity, we search for consistencies. We compare our column densities for OH^+ with the OH^+ column densities of the Krelowski et al. paper (2010) and expand that survey to 41 stars. We want to further understand cosmic-rays ionization in space by extracting the rates from the OH^+ data.

Adam Smercina, "*After the Fall – Dust and Gas in Post-Starburst Galaxies*," (J.D. Smith)

Atomic, Molecular, Optical Physics

Peter Jones, "*Semi-Empirical Methods of Intermediate coupling in electrons of atoms in Iso-Electronic Sequences*," (Larry Curtis, David Ellis, Richard Irving)

Examinations of iso-electronic sequences reveal trends in intermediate coupling as one travels up the sequence in order of ascending atomic number. These trends, once analyzed, were modeled and predicted for the ground np3 configuration in the N and P sequences. By fitting the observed energy intervals in terms of the Slater and spin-orbit parameters F, ζ, we formed the Hamiltonian energy matrices in pure L-S coupling basis. From the resulting eigenvectors we predict the mixing amplitudes and the resulting M1 transition rates. Although further tests remain, the code developed is promisingly accurate in accordance with NIST energy- level values for the full range of the sequence up to at least Tungsten. The software utilized was a combination of Maple, Excel, and Multi-configuration Hartree-Fock calculations. Another project examined spectral and decay curves of S II and Pb II to reveal transition probabilities, oscillator strengths, and potential cascades. These decays are of general interest to the scientific community and Pb II is of particular interest to astronomers studying diffuse matter and galaxy formation. Further data decay is needed to strengthen the signal and increase accuracy but initial results are promising. Data was obtained from THIA (Toledo Heavy Ion Accelerator) and processed with Root version 3.2b, Excel, and Lab View.

Condensed Matter Physics

Derek Brinkman, "*Spectroscopy Ellipsometry Studies of Vanadium Oxide Nanocomposite Etching*," (Nikolas Podraza)

This report looks at the creation of a model that dynamically fits in situ ellipsometric spectra collected during the etching of nanocomposite Vanadium Oxide (VOx) samples by a solution of water and over-the-counter (OTC) hydrogen peroxide. Two samples with different thin film resistivities and amorphous + nanocrystallite compositions were etched at two different hydrogen peroxide concentrations. Three different structural models were evaluated to describe the etching of these films. For these VOx thin films on silicon substrates, the more amorphous VOx etched almost 30 % faster than the predominately nanocrystalline VOx. The more amorphous VOx etched at an average rate of 1.76 A/sand the more nanocrystalline VOx etched at an average rate of 1.27 A/s. These measurements were all taken in the visible spectra. This report will highlight the procedure involved, the models used, the results that were gathered, and further work that can be done to gain further knowledge of VOx.

Adnan Choudhary, "*Strain Analysis in Submonolayer Cu/Ni(100) - Continuum and Atomistic Perspectives*," (Jacques Amar)

We compare LLL continuum theory predictions for submonolayer Cu/Ni(100) growth to results from atomistic simulations using EAM potentials. Results show that LLL continuum theory is unable to predict the exponential behavior for strain in the substrate that is observed in atomistic simulations. As a result we question the application of LLL theory for film applications.

MeiXing Dong, "*Structural and electronic properties of β-Ga_2X_3 (X=O, S, Se, Te) using ab initio calculations*," (Sanjay Khare)

I participated in on going work in Prof. S. V. Khare's group studying the structural, electronic and energetic properties of Al_{2}X_{3}, (X = O, S, Se, Te), in the I4_{1}/amd space group. The study was done using density functional theory (DFT). I helped a graduate student to analyze structural models of the material which came as output from DFT computations. I tabulated some of these results and compiled data for different materials from existing files.

Anthony Passero, "*Synthesis of Cu_2O and Cu_2S Thin Films for Photovoltaic Application*," (Yanfa Yan)

Thin films of the P-type materials Cu_2O and Cu_2S are synthesized and characterized for use in photovoltaic application. Cu_2O films were synthesized on copper substrates using a thermal oxidation method. Following this, CdS films were synthesized using a chemical bath deposition (CBD) for use as an N-type material in a completed Cu_2O solar cell. The CdS films were deposited onto glass substrates, to optimize the deposition parameters. Characterization of these two films was performed, but not by myself (due to my shift to the Cu_2S project) and as such is not discussed in this paper. Cu_2S films were synthesized onto borosilicate glass (BSG) using sputtering deposition, in order to optimize the deposition parameters. Characterization was used to determine thickness, electrical properties, optical properties, grain morphology, and composition. The data is not yet completely analyzed, but preliminary examination suggests optimal sputtering deposition under high temperature (220ºC) and low pressure (5-10 mTorr).

Morgan Vasilakes, "*Investigating Process Parameters of Cadmium Telluride Solar Cells*," (Michael Heben)

This summer I studied the effect of changing our process parameters for cadmium telluride (CdTe) solar cells. There are two processes that I focused on. The first one is called the cadmium chloride ($CdCl_2$) treatment. The other process is called the annealing process. We already had parameters, but the problem with this was that no one really knew where those numbers came from. It was just what they had used before and kept using. I did three main experiments. In the first one I studied the effect of changing the annealing temperatures and time. I found that doing the annealing process for 30 minutes at 200°C gave me the best efficiency. In my second experiment I wanted to confirm the results from the first experiment. This did not happen. In this experiment 30 minutes at 225°C gave me the best efficiency. In my third experiment I studied the effects of changing the $CdCl_2$ treatment temperatures as well as the annealing process temperatures. In this experiment I found the best efficiency when I did the $CdCl_2$ treatment at 410°C and the annealing process at 225°C. Now we know there are better parameters to use, we are just not sure which are the best. One way this can be determined is by doing more experiments and therefore obtaining a larger amount of data.

Medical Physics

Kathleen Connolly, "*The Future of MRI and PTSD*," (Michael Dennis)

During my research this summer I joined a group of students and professionals on their research team. This group of scientists were interested in learning if there is anything in the brain that will predetermine if you are more likely to develop Post Traumatic Stress Disorder after a traumatic event. While I was here over the summer, the research team was working on gathering a group of test participants and moving their fMRI images into a program where all of them can be compared and normalized. An fMRI works exactly like an MRI, using strong magnetic fields and radio frequencies that interact with hydrogen protons, to create an image. The fMRI instead of looking at an entire body, looks only at the brain and differentiates between areas that are being activated and ones that are not in use. It does this by looking at the flow of blood to different areas in the brain and differentiating between the deoxygenated and oxygenated blood, since they have a different magnetic susceptibility. The test participants had all been in a car accident and were given three stress level tests over a period of twelve weeks. They had two fMRI's, one hours after the time of the incident and one at the end of the twelve week period.

Mackenzie Endres, "*Simulation of the SAVI, Strut Adjusted Volumetric Implant, Brachytherapy Treatment*," (David Pearson)

The Strut Adjusted Volumetric Implant, SAVI, is a relatively new device for breast cancer treatments. The goal of this project was to create a model of the geometry of the device and a template for actual treatment plan simulations. The template will work in mcnp5, the newest Monte Carlo N-Particle code used for neutron, photon, electron, or coupled neutron/photon/electron transport, to create accurate dose distributions of normalized breast cancer treatments. The mcnp5 results will be useful as a second check of the treatment plan to verify that accurate doses could be delivered to SAVI treatment patients.

Ruslana Sistryak, "*Effect of Beam Configurations in Treatment of Nasopharyngeal Carcinoma*," (E. Parsai)

The goal of this project was to develop the best possible treatment for a given nasopharyngeal carcinoma (NPC). We CT scanned a Rando Phantom's head and neck (H&N) region and transferred the scans into our treatment planning computers. We created a gross tumor volume (GTV) in the nasopharyngeal area and expanded it to make a planned treatment volume (PTV) with appropriate margins and contouring critical structures in the area. Using 3D conformal radiotherapy technique (CRT), we created an optimized deliverable plan with proper blocks around each beam to save the critical structures. Then we created an intensity-modulated radiotherapy (IMRT) plan using the contours that we had. We reviewed the dose volume histograms (DVHs) for the target NPC, and for organs at risk (OARs) that we had delineated, and made comparisons.

Finally, we made diode measurements to verify that the plans were accurate and deliverable.

Plasma Physics

Nathan Diemler, "*Characterization of argon plasma energies by comparison between Langmuir probe and optical emission spectra*," (Alvin Compaan)

Plasma characteristics in magnetron sputtering deposition are the topic of interesting this research project. The variation in plasma optical emission and plasma temperature are examined at various deposition pressures and radio frequency (RF) powers. The goal is to find a relationship between the ratio of two optical spectral lines and the electron temperature. Plasma characteristics are analyzed through use of a Langmuir probe and diode-array spectrometer.

Abstracts of Additional UT Summer Research Students

Michael Huebner, "*Searching for Binary Stars in the Orion Molecular Cloud,*" (Thomas Megeath)

Tyler Kinner, *"Synthesis and Characterization of FeS_2 Quantum Dots,"* (Randy Ellingson)

Pyrite (FeS_2) is a novel, promising material for use in photovoltaics. Earth-abundant, non-toxic, and easily processed (through a quantum dot method), pyrite adds sustainability to the solar renewable energy field. With indirect and direct band gaps of approximately 0.9eV and 1.3eV, respectively, pyrite is appropriate for band gap tuning to suit AM1.5G (the standardized solar radiance at the Earth's surface). Several syntheses have been developed for producing pyrite quantum dots, namely thermal injection methods yielding crystalline, well-passivated, and phase pure quantum dots. Another method, an inverse-micellar synthesis, is used to yield monodisperse, quantum-confined pyrite quantum dots. Further work is also being performed to create photoresponsive films of the quantum dots.

Joseph Ozbolt, *"A Theory of Multilayered Thin-Film Radiation Detectors,"* (Victor Karpov)

The goal of our project was to develop a theory for a new type of multilayered thin-film radiation detector with N>>1 micron thick cadmium telluride (CdTe) semiconductor layers stacked on top of one another. The research conducted this summer only dealt with the one layer case for which physical intuition was pursued. Between each layer is either an aluminum or copper plate connected to terminals that may reveal certain data about particles' nature, energy, dispersion of spectrum and the angle of incidence. Several Monte Carlo simulations were ran for the single-layer case of different thicknesses for 2MeV and 4MeV photons. Results were then analyzed.

Jakub Prchlik, "*A Spectrographic Study of CepOB3b*," (S. T. Megeath)

Presented is data obtained from the Hectospec and Hectochelle instruments located at the MMT in Mount Hopkins, Arizona. The Hectospec instrument was used to obtain moderate resolution spectra of ~1900 sources. The Equivalent Widths (EW) of several features were measured, as well as the spectral type for these sources. Data was able to be gathered from the sources concerning the age, luminosity class, and accretion. Using the Hectochelle instrument the Hα Full Width at Ten Percent Maximum (FWTPM) was determined for 41 previously identified Class II sources. The FWTPM then can be used to estimate the accretion rates. Accretion rates are important for understanding how gas evolves in a star disk system.

Steve Solomon, “*Globular Cluster Detection and Planetarium Experience*,” (Rupali Chandar)

My REU experience this summer can be characterized by two different experiences that will greatly benefit me this next school year and into the future. My first experience consisted of undergraduate research under the supervision of esteemed professor, Dr. Rupali Chandar. This research was a continuation of research from last summer and last school year. Work in this area consisted of finding globular clusters. Analyzing data from this summer in terms of color-color plots and luminosity will be work accomplished next school year. My second experience involved working in the planetarium under Alex Mak and graduate student Cody Gerhartz. I learned many things at Ritter Planetarium and Brooks Observatory including how to: use the SciDome XD projector, use the program Starry Night to write ATM scripts (planetarium shows), play full dome Spitz content shows,give live public planetarium shows, and give live viewing presentations using Brooks Observatory. I also helped to work in public outreach programs that Ritter Planetarium and The Department of Physics and Astronomy hosted. I will also talk about some ideas that I am throwing around as far as some possible future publications in astronomy and in the field of education. Lastly, there are many acknowledgements that will need to be addressed.