ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2009
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Casey T. DeRoo, *LDN 1780: A Translucent High-Galactic Latitude Interstellar Cloud in a UV-rich, Anisotropic Radiation Field,* (A. Witt)

We combined high-resolution optical imaging observations in 12 intermediate-band (BATC) filter and deep mid- and far-IR Spitzer maps of LDN 1780 to characterize the external radiation field illuminating this high-latitude (l = 359 deg; b = 36.5 deg; distance ~100 pc) translucent cloud and the infrared emission of dust within LDN 1780 in response to this external illumination.

The overall energy density of the incident radiation field is approximately equal to that of the ISRF near the Sun, resulting in a large dust grain equilibrium temperature ranging from 14.5 K -16.8 K. However, the incident radiation field is highly anisotropic, with the southern portions of LDN 1780 being most strongly illuminated, especially at shorter wavelengths. This anisotropy is a result of the cloud's proximity to the Sco OB2 association (est. center: l = 322 deg; b = 10 deg).

The southwestern portion and the optically-thin eastern tail of LDN 1780 exhibit strong intensity excesses at 24 micron (Spitzer MIPS) and at 8 micron (Spitzer IRAC Ch. #4) compared to dust in the diffuse ISM of the Milky Way Galaxy. We interpret these excesses as enhanced emission from stochastically-heated very small grains (VSG) and from PAH ions, respectively. These excesses, however, are not necessarily the result a greater relative abundance of these two small-particle components but rather reflect the increased frequency of photon-grain interactions (e.g. heating, excitation, or ionization) within a UV-rich radiation field.

Rachell Gestrich, *The Stellar Content of the Starburst Galaxy NGC 3125, (R.Chandar)*

Star clusters are a group of gravitationally bound stars that are formed at the same time and have the same metallicity. Each cluster can contain from a few hundred to hundreds of thousands of stars and therefore are much brighter than individual stars. We can measure their ages, masses, and sizes and use this information to trace the star formation history of their parent. I used images from the Advanced Camera for Surveys on the Hubble Space Telescope, to study the content of the dwarf starburst galaxy NGC 3125. I performed aperture photometry on all objects detected in the images, and used various criteria to separate star clusters from individual stars, blends of a few stars, and background galaxies. I found that the galaxy is dominated by luminous, young (<10 Myr) clusters, with fewer older clusters.

Marina Kounkel, *The search for protostellar binaries in Orion*, (T.Megeath)

What is a star? It is a massive ball of mainly hydrogen that is held together by its own gravity. Why is it important to study stars? They produce energy and all the elements heavier than hydrogen through nuclear fusion. Planets are a byproduct of stellar formation. Without stars life couldn't possibly exist, thus they are imperative for understanding the origins of life. Stars have finite lifetimes. They form; they live; they die. Their lifespan can last from a few millions to many billions of years, depending on their mass. The Sun was formed approximately 4.6 billion years ago. We cannot revert time, but by studying other stars in the process of the formation we can recreate the history of what happened during that era.

Corbin Taylor, *Li in IC 443,* (S.Federman)

Supernovae are believed to be important to the chemical evolution of the Galaxy. In particular, they play a role in the production of the light elements Li, Be, and B which are thought to be produced via pathways that differ from elements synthesized in stellar cores. In our study, we reduced and analyzed data from the 9.2 m Hobby-Eberly Telescope (HET) (R=98000) for two sight lines in the vicinity of the supernova remnant IC 443, toward the OB stars HD 254577 and HD 254755. We focused on the Li I doublet around 6808 Å to find the value of the column density ratio of the two isotopes of Li: N(Li-7)/N(Li-6). We also used HET data for the CH spectral line at 4300 Å as an aid in the fitting process. The goal of this research is to further our knowledge about Li and the elements in general.

Maverick Terrazas, *Infrared Variable Stars in the Small Magellanic Cloud using the Spitzer SAGE-SMC Survey*, (U. Vijh)

I am presenting my search for variable stars in the Small Magellanic Cloud (SMC) using the observations made by the Spitzer SAGE-SMC Legacy program. Three epochs of data were used, two of which taken 3 months apart and one taken three years before. Each epoch was taken using two infrared imaging instruments on the Spitzer Space Telescope: the Infrared Array Camera (IRAC) and the Multiband Imaging Photometer for Spitzer. I found 825 sources that meet the variability criteria defined: a source must have $|V_{band}| > 3$ in at least two neighboring bands in the same direction. These sources were, then, plotted on color magnitude diagrams for classifying. 57 sources have been visually verified as variable out of the 80 sources checked.

Atomic/Molecular/Optical Physics

Sean Maddock, *Lifetime measurements in P II using beam-foil spectroscopy,* (M.Brown, L. Curtis, D. Ellis,S. Federman,R. Irving,C. Theodosiou)

Beam-foil spectroscopy is a useful method for studying temporal elements of atomic structure and properties, such as lifetimes of excited states. Studies this summer were done using the Toledo Heavy Ion Accelerator (THIA) studying the $^3P_0$ $3s^23p^2$ – $^3P_1$ $3s3p^3$ transitions in P II. Using a forward lifetime measurement at 170 keV, a lifetime of 13.94 ± 0.59 ns was measured for the J=1 upper state at λ=1301.87Å. This is a very good measurement as shown by the reduced chi-squared and in that the uncertainty of the measurement is within 5%. Future measurements are planned using a reverse lifetime measurement and another forward lifetime measurement at 220 keV.

Sean Maddock, *Theoretical calculation of polarizabilities using variational theory,*(M.Brown, L. Curtis, D. Ellis,S. Federman,R. Irving,C. Theodosiou)

Theoretical work was also done this summer in calculating atomic dipole polarizabilites. By using the variational principle and a trial wave function, the energy of a system can be minimized to obtain an approximate solution for the complicated system. This method was used to determine a new method of calculating polarizabilites of atoms or ions with a closed-shell core. Results were promising and showed trends of agreement with literature values. More time would be needed to include more parameters in the calculations to improve future results.

Biological, Health, and Medical Physics

Catherine McGuinness & **Lydia Michaels,** *The World of fMRI and LabVIEW*,(M.Dennis)

In our ten-week research program here at the University of Toledo Medical Center, we worked in many different fields of the Medical Physics department. In the first five weeks of the summer, we analyzed the results of different smoothing functions on CT scans. CT stands for "computerized tomography." CT scans are also commonly referred to as CAT scans, from the original phrase, "computer-assisted tomography." A CT scanner is a very sophisticated x-ray machine. The patient lies on a table that is cantilevered through the scanner gantry. The gantry houses the x-ray source across from a fanned detector array. This setup rotates around the patient several hundred times per second as the patient is moved through the gantry producing helical scans. With reconstruction software, a user can produce both slice scans and three-dimensional images. Different tissue types register as different

CT numbers, which the computer uses to visualize the patient's internal organs. Air is assigned the number -1000 and always appears black. Water is defined to have a CT number of zero while bone is approximately one thousand.

Condensed Matter Physics

Stephanie Ash, *Improving the a-Si:H and nc-Si:H Back-Reflectors Modeled with ZnO Stacks***,** (Robert Collins)

This report looks to find the best model that will give the optimal reflectance from the ZnO, least absorption in the Ag, most absorption in the Si and the least amount of total reflection by creating a multi-layer ZnO with alternating indices of refraction on a Ag back-reflector. The ZnO high is an intrinsic ZnO and the ZnO low is created theoretically by introducing more free carriers modeled by the Drude behavior in the ZnO dielectric functions. Later, ITO layers with alternating indices of refraction were also placed in the model to improve its performance. The best results are shown and discussed. Finally, some suggestions of work that could be further made on this project are presented.

Becky Carlson, *Optimization of Indium Tin Oxide (ITO) by Pulsed DC Power on Single Junction Amorphous Silicon (a-Si) Solar Cells*, (Bill Ingler)

Using pulsed DC power, conditions at which production of a thin indium doped tin oxide film were achieved to produce the optimal efficiency for an amorphous silicon solar cell. Thin films of indium doped tin oxide were prepared by plasma vaporization (PEVCD) deposition using a pulsed DC power supply. Power, deposition time, pressure, gas flow and temperature were changed to find the optimal conditions. The best films were produced at a power of 40W, deposition time of seven minutes and 40 seconds, a pressure 4.0mTorr, gas flow 16sccm and at 151 °C and had 0.25 cm^2 dots with an efficiency of 6.650% (SD2785-2.12). Also, the ITO was put on a germanium silicon solar cell with an efficiency of 7.203% (SD2786-4.32). The surface morphology was compared using atomic force microscopy between 35, 40, 43W and the lower power had a lower root mean square roughness curve than the higher power samples.

Tyler Hill, *A photoluminescent study of $CdCl_2$ treated CdS/CdTe thin film photovoltaic cells of varying CdTe thickness.***, (**A. Compaan/K. Wieland)

$CdCl_2$ treated CdTe/CdS solar cells have some of the highest efficiencies of any cells currently available. In order to further improve cell efficiencies an improved theoretical understanding of the different recombination mechanisms present in the cell is essential, and photoluminescence studies are one of the easiest nondestructive methods of obtaining such information. We find evidence for an exciton transition due to CdTe at 1.595eV and a corresponding 1.553eV transition due to $CdTe_{0.94}S_{0.06}$ with the 42meV difference in Te/S replace position is consistent with the band bowing of the alloyed material. The replace follows a temperature dependence of $-3x10^{-4}$eV/K for temperatures above 30K, which is consistent with the temperature shift of the CdTe bandgap for temperatures above 30K.

Rosa Zartman, *Spectroscopic Ellipsometry study of Transparent Conducting Oxides* (S. Marsillac; J Walker)

This research focuses on using indium tin oxide (ITO) and aluminum doped zinc oxide (AZO), to make a transparent conducting oxide for copper indium gallium diselenide (CIGS) photovoltaic solar cells. To accomplish this feat, the employment of a RF Magnetron Sputtering System by a Kurt J Lester PVD75 sputter with 3in ceramic targets is the process of choice. The system was placed under high vacuum by a cryogenic pump. The necessity of using a transparent conductive oxide (TCO) at the top of the solar cell comes from the requirement of having the light passing through (hence the transparency) while being able to conduct the electrons out of the cell into the load (hence the conductivity). The ITO and AZO films were deposited on soda lime glass and on silicon wafer. The power and DC bias applied to the deposition were varied to try to optimize the transparency and the resistivity. The duration of the deposition was also changed in order to achieve a film thickness of about 300 nm. The films were then studied for their transmission, reflection, resistivity, and other optical properties using a spectrophotometer, a four-point probe, and an ellipsometer in the solar spectral range and in the deep IR.

NSF-REU External Publications and Presentations*

(Update from Annual Report 2008)

REFEREED PUBLICATIONS - Submitted/accepted/published.

Yunsic Shim, **Mary E. Mills* (2007)**, Valery Borovikov, and Jacques G. Amar, "Effects of substrate rotation in oblique-incidence metal(100) epitaxial growth," Physical Review E 79, 051604 (2009)

Ingler Jr, W. B.; **Ong, G.* (2007)**; Deng, X. "RF Sputter Deposition of Indium Oxide – Iron Oxide Films for Photoelectrochemical Hydrogen Production" *ECS Trans.* Vol. 16, No. 7. (State-of-the-Art Program on Compound Semiconductors 49 (SOTAPOCS 49), **2008**, 49.

REFEREED PUBLICATIONS - in preparation.

PRESENTATIONS.

Ingler Jr, W. B.; **Ong, G.* (2007)**; Deng, X. "RF Sputter Deposition of Indium Oxide – Iron Oxide Films for Photoelectrochemical Hydrogen Production" *ECS Trans.* Vol. 16, No. 7. (State-of-the-Art Program on Compound Semiconductors 49 (SOTAPOCS 49), **2008**, 49. *210th Meeting of the Electrochemical Society*, *Inc.*, Honolulu, HI, October 12-17 (Oral Presentation)

PRESENTATIONS WITH PUBLISHED ABSTRACTS.

CONFERENCE PRESENTATIONS WITH PROCEEDINGS PAPERS.

R. M. Zeller (2008), J. D. Walker, K. A. Wieland, and A. D. Compaan, "R*eal-time Optical Thickness monitor for Thin Film Growth,"* 34th IEEE Photovoltaic Specialists Conference Philadelphia, PA, June 7-12, (2009)

REU students' names in **bold face type*** with year of participation.