ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2004
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Erin Allgaier, *"Stellar Wind Variability of alpha Cygni,"* (N.Morrison)

We take a look at the star a Cygni and observations taken of the star over three seasons at Ritter Observatory at the University of Toledo. Alpha Cygni is a class A2Iae star that is losing mass creating a P Cygni profile. Using a 1-meter reflecting telescope, an échelle spectrograph and a CCD, data are taken of the star. The 1998, 1999, and 2000 observing seasons are examined for a total of 151 spectra. For each spectrum, telluric lines are removed, cosmic rays and electronic defects are removed, the Doppler shift is corrected, and continuum is normalized. The accumulation of the analysis is represented in three dynamical spectra. From the dynamical spectra, periodic behavior is attempted to be found, verifying or opposing the theory of periodic wind behavior due to increased mass loss at specific locations on the star.

Adam Kowalski, *"Infrared Spectra of Be Stars,"* (K. Bjorkman)

Using the Spex spectrograph mounted on the Infrared Telescope Facility (IRTF), Dr. K. Bjorkman, Dr. J. Bjorkman, and John Wisniewski took infrared spectra (0.85 microns to 2.5 microns) of about 30 Be stars, which are stars that are known to have circumstellar gaseous discs around them. I have used an IDL program called SpexTool to reduce the raw data from the observing run and produce finalized spectra of each of the stars on the second observing night. From the equivalent width and full-width-at-half-max of the emission features in the spectra, we are in the process of deducing each disc's orientation, elemental composition, rotational motion, and behavior of its density waves. We found that 48 Libra's V/R variation is similar between the Hydrogen alpha emission taken at Ritter and the Hydrogen Brackett series taken in the infrared, which tells us that the density clump is generally uniform at different radii of the disc. The results will give insight into the physics of many disc systems ranging from the rings of Saturn to the spiral arms of galaxies.

Paul Sell, *"Exploring the Excitation of Extended Red Emission,"* (A. Witt)

Extended Red Emission (ERE) is a photoluminescence process that was first detected in the Red Rectangle at wavelengths between approximately 600 and 800 nanometers. Many properties of the nature of ERE have remained a puzzle for decades. Theorists have suggested models for numerous carriers of this complicated emission, but none of the models have thoroughly accounted for the emission. Our data consists of observations with the Hubble Space Telescope (HST) of the dust filaments in a photodissociation region in NGC 7023. We use the known exciting radiation value of 1104 Å for H_2 fluorescence and infrared (I) band observations to find the exciting radiation for the ERE. We used ratios of the relative penetration depths of the H_2 and I bands to the ERE and found the spectral region for the exciting radiation for the ERE to be in the far UV (ultraviolet).

Atomic/Molecular/Optical Physics

Jennifer Hawk, *"Measurements of Kinetic Energies Using Hemispherical Energy Analyzers,"* (T. Kvale)

Two electrostatic energy analyzers are employed on the UT-P/NIELS accelerator facility at UT in order to measure the kinetic energies of ejected electrons and scattered energetic ion projectiles following ion-atom and ion-surface collisions. This project involved accurate modeling of the ion and electron trajectories entering and exiting the analyzers in order to achieve the high energy resolution necessary for the current atomic scattering experiments.

Jack Steiner, *"Isoelectronic Modeling of Energy Levels and Emission Intensities in the Mg sequence,"* (L. Curtis)

A new model has been developed for calculating branching fractions along the Mg-like isoelectronic sequence. By adjusting the $^1D_2$ energy level in the $3p^2$ and 3s3d configurations in order to minimize differences between Slater off-diagonal and diagonal spin-orbit energies, close agreement is obtained with MCHF calculations. The results of this investigation show little configuration interaction (except for the singlet D) and nearly pure LS coupling between energy levels. Use of this model has led to interesting questions of what it means to have imaginary mixing angles and investigations of modeling imaginary parameters. Further investigation is being done into semi-empirical modeling of Slater parameters in order to accurately model energy levels along the Mg-like sequence. Subsequently, this technique may be useful for modeling Zn-like and possibly Ca-like sequences.

Victoria Winbow, *"Applications of Semi-Classical Methods to Molecular Spectra,"* (B. Gao)

The usual WKB method does not perform well for highly excited states of molecular spectra. Our method is a modified WKB in which a local scaling transformation is made, and then the traditional WKB method is applied to the transformed problem. This method was tested on a class of Lennard-Jones potential.

Condensed Matter Physics

Levi Gorrell, *"Temperature Dependent Photoluminescence of Ion Implanted Crystalline CdTe,"* (A. Compaan)

We have used ion-implanted CdTe crystals to study the photoluminescence (PL) signature of specific dopant atoms in this semiconductor. The crystals were prepared by graduate student, Xiangxin Liu, using ion implantation to introduce controlled densities of dopants and then annealed to remove the implantation-induced damage. I measured the temperature dependence of the PL from room temperature to 10 K using argon-ion laser excitation and the intensity and spectral shifts were studied to help identify the origin of the PL lines and bands including the energies of the impurity-bound excitons and the donor-acceptor pair luminescence.

Arow Hieronymus, *"Effects of Shadowing and Diffusion on Surface Morphology in Thin-film Growth,"* (J. Amar)

Recent experiments on vapor deposited CF_2 thin-films have shown a power-law distribution $P(\Delta h)$ for nearest neighbor sites height-differences (Δh) where $P(\Delta h) \sim (\Delta h)^{-\eta}$, and η . 4.6. In order to understand this we have studied the effects of shadowing and diffusion on thin-film growth by sputter deposition using four distinct models in two and three dimensions. Our simulations indicate that both shadowing and sideways growth (overhangs) are necessary to observe a power-law distribution of the height-difference. For the case of "cosine" distribution we found that in two dimensions η . 2.6 and in three dimensions η . 3.1. We also observed shadowing and sideways growth lead to a porous film and anomalous scaling of the height difference correlation function.

Joshua Inks, *"Analysis of the Optical Properties of the Component Layers of the CdTe Solar Cell,"* (R. Collins)

With the application of rotating compensator ellipsometry and powerful data analysis software, a detailed interpretation of the optical properties of the component materials used in thin film solar cells has become possible. To this end, I have adopted this methodology to begin the characterization of the optical properties of the component layers of a CdTe solar cell. The CdTe solar cell consists of a substrate of soda-lime glass with layers of a transparent conducting oxide (TCO), SnO_2, along with CdS and CdTe, deposited onto it. My task was to parameterize the optical characteristics of the glass substrate and the TCO. In general, this was accomplished by fitting the data to a simple Cauchy function for the spectral range over which absorption could be considered negligible, in order to determine the thickness of the layer, and then fixing the thickness and fitting the data to a more sophisticated model consisting of a sum of Lorentz oscillators to determine the optical properties over the full range. The parameterization of the optical properties of each component of the cell will be useful in on-line analysis of completed solar cells measured at the solar cell factory.

Nicholas Sperling, *"Simulations for Experiments on Nano-Magnetic Materials,"* (A. Lukaszew)

The analysis of nanometer sized structures is a difficult proposition, particularly analyzing the internal magnetization of structures made on magnetic materials. Using the Object Oriented Micro Magnetic Framework (OOMMF) released by NIST, it is possible to simulate structures on the nanometer scale to aid in understanding results from indirect analysis methods, such as Magneto-Optical Kerr Effect (MOKE) measurements, which cannot directly analyze surface morphology. This technique was used to create simulations of nanometer sized bridges on Nickel in multiple crystallographic directions in an attempt to offer support to domain wall trapping at the nano-contact. Simulations were also run using "The Stopping and Range of Ions in Matter" (SRIM), to determine the energy and current required to inject Chromium ions into a Zinc Telluride sample, in an attempt to create a room temperature ferromagnetic semiconductor.