ABSTRACTS OF REU FINAL REPORTS
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Implementing a Energy Analyzer on UT -P/NIELS

Student: Blake Anderson
Advisor: Thomas Kvale

Abstract:

The energy analyzer installed in the UT -P/NIELS accelerator at the University of Toledo produced data, which was inconsistent from what was expected. The energy analyzer supported the fact that two different values of energy were going through the hemispherical energy selector. This supported the fact that the optics of the deceleration column, the zoom lens, and the energy analyzer was a focus of a hollow beam at the entrance of the hemisphere. Simion 6.0, a computer program that numerically solves the Laplace Equation to produce simulations of ion trajectories was used to create all models in this study. Through the creation of different models, in Simion, it was found that the hollow beam was being created. A hollow beam is created by a combination of multiple focal points and large spherical aberrations. In comparison the first focal point in a system is much tighter than that of the second and third of which the focus has been spread out. There are also large spherical aberrations created by equipotentials, which do not have one radius of curvature.

Measurements of Carbon Monoxide Abundance in Diffuse Interstellar Gas Clouds

Student: Thomas Crenny
Advisor: Steven R. Federman

Abstract:

In this project the abundance of carbon monoxide in gas clouds toward bright stars was obtained and will be used for input into chemical models. The ultraviolet data were obtained with the Copernicus Satellite in the 1970's. My re-analysis of the data was done because there are now more sophisticated tools available to extract column density, Doppler shift, and excitation temperature and more precise molecular data. The goal of the project was to determine approximately how much CO, the second most abundant molecule in the universe, exists in interstellar gas clouds toward bright stars such as Delta Sco and Alpha Cam. The column densities were found to be in the range of $8x10^{11}$ to $6x10^{14}$ molecules cm^{-2}. These values were compared to the column densities of other molecules such as H_2, CH, and CH^+ as an aid to understanding the chemistry of diffuse interstellar gas clouds.

Spectroscopy of Be Stars Kappa Draconis and 60 Cygnus

Student: Kevin V. Croxall
Advisors: Nancy D. Morrison, and Karen S. Bjorkman

Abstract:

New spectroscopic data for Be stars K Dra and 60 Cyg were collected and analyzed. For purposes of clarifying data, by removing water lines, a library of telluric calibration files, for use at Ritter Observatory, were created. Of special note is the loss of emission by the star 60 Cyg in the month of June 2001. Equivalent width of the Ha line, radial velocities, delta V, V/R quantities and polarization data were analyzed to reveal new periods for each star. While the periods are still in preliminary stages, the periods seem very promising. Most striking is an apparent period of about 2000 days in the equivalent width of κ Dra. Data is also suggestive that the 61.55 day period of κ Dra may not be due to binary motion as was previously reported. Strong evidence for a correlation between the equivalent width of the Hα line and the polarization is found. Possible implications on the evolution of the star are discussed.

Be STARS: Modeling their Polarization and Infrared Excess with Respect to Inclination and Optical Depth

Student: Amanda C. Gault
Advisor: Karen Bjorkman

Abstract:

The circumstellar disks of B-type emission line stars polarize the light emitted by the star and also cause there to be an excess infrared radiation. The observed polarization and infrared excess are affected by the inclination and the optical depth. We modeled the effects of these two parameters on the polarization and infrared excess of Be stars of 5 stellar radii with a stellar temperature of 25,000 K and a disk temperature of 19,000 K. The resulting model gave us a grid system with lines of equal inclination and equal density. Our model reproduces the distinct triangular shape characteristically seen in empirical plots of observational data. Also, an explanation for the upper limit of the polarization can be drawn from the model. Once the inclination reaches 70° to 75° the polarization reaches a maximum of 2% and then decreases again at higher inclinations until, nearing 90°, the polarization is about half of its maximum value. Thus, the upper limit of the diagram is created by a combination of the maximum polarization produced and the maximum infrared excess resulting from a specific model. We carried out a preliminary comparison of our model results with observational data by overplotting data points onto the model grid. However, the interpretation of the model results and comparison with observational data will require additional model runs to be made for stars of other sizes and temperatures. This will be carried out in future work continuing this project.

Functional MRI, Data Analysis for Image Production

Student: Todd M. Hill
Advisors: Thomas Kvale, University of Toledo and Michael Dennis, Medical College of Ohio

Abstract:

Magnetic Resonance Imaging (MRI) has become one of the most powerful and widely used techniques in neurological imaging. Most often, it is used to create highly detailed anatomical images that can be used by physicians for identification and diagnosis of physiological problems. With some manipulation of the MRI signal though, one can obtain images representative of brain activity (BOLD imaging) and/or blood flow via perfusion analysis. This technique is termed functional MRI (fMRI).

From May to July of 2001, I was allowed the opportunity to work with Medical Physicist, Dr. Michael Dennis on a funded project exploring the possibility that migraine headaches may predispose certain individuals to stroke by identifying cerebral arterial narrowing. In this case, the objective of the medical physicists was to use a powerful new software package, entitled MedX, to analyze to fMRI data and to produce images useful in supporting the hypothesis.

The primary goal was understanding and implementing the MedX software. This proved more difficult than planned. As it turns out, using the software required more than just opening MRI image data files and clicking buttons. When a MRI scan is performed, the imaged are saved in sequential order (slice 1 is followed by slice 2 and so on, in the order they were produced). When the image files were first opened in MedX, they did not appear in the proper sequence. We found out that when the files were converted to DICOM format, the file transfer standard, the file names were also changed. The reason this is a problem is due to the naming format. Each file was named numerically starting with image 1. The problem lied with the fact that the software could not sort the files numerically. What was needed was to add preceding zeros to the file names in order for them to be sorted. File 1 became 001, file 2 became 002 and so on. After this was done, the data analysis could continue.

A future requirement for implementation of this software requires an automated file renaming procedure to minimize analysis time. This will be accomplished by using tools provided with the MedX software (which has yet to be found) or by writing a Linux OS based computer program to perform the renaming outside of MedX. By doing this, the data analysis will be completed in a timely manner providing the medical researchers quality perfusion based images that are necessary for identification of cerebral arterial narrowing.

Photoluminesence of CdTe Films: Varying Sputter Targets, Substrates, and Annealing Conditions

Student: Kathleen Hinko
Advisor: Alvin D. Compaan

Abstract:

We altered several parameters relating to the CdTe layer in CdTe-based solar cells and analyzed the effects of these changes on low temperature photoluminescence. Polycrystalline CdTe films were grown by radio frequency sputtering from three different targets, two purchased commercially and one pressed at the University of Toledo, as well as on two different substrates, soda lime and borosilicate glass. Samples from the films were either kept as a control or were annealed in the presence of $CdCl_2$ in the conditions used for solar cell fabrication. The purpose of the $CdCl_2$ treatment was to increase PL and facilitate comparisons with future studies. We then compared photoluminescence spectra from the various samples. The PL results suggest that films grown from the UT target were of comparable quality to those grown from commercial targets. Also, a comparison between the films grown on different substrates shows much weaker PL for borosilicate glass versus soda lime glass. This may indicate that the sodium in the soda lime glass has a positive effect on the PL of the CdTe film.

Construction of a MOKE Station using Lab-View

Student: Brandon McNaughton
Advisor: R. Ale Lukaszew

Abstract:

Magnetic thin films and mu1ti1ayers containing layers of magnetic material have generated a large amount of interest in recent years due to the richness and complexity of their magnetic spin configuration. In addition, nano-magnets are very attractive for their possible application to magnetic-data-storage. A powerful technique to study the magnetization reversal behavior of magnetic thin films is MOKE (magneto-optic Kerr effect). The magnetic field required for magnetization switching (i.e. the coercive field) can be obtained from MOKE measurements. A convenient setup for ruming MOKE experiments utilizes Lock-In techniques and can be computer controlled and automated using Lab- View software. Such setup was developed at the Physics Department at the University of Toledo and was utilized to study the azimuthal dependence of the coercive field in epitaxial, annealed and non-annealed Ni films grown using MBE (molecular beam epitaxy) on MgO substrates. These studies allowed the correlation between the different surface morphology observed in these films with their magnetic properties. These studies will be relevant to a bigger project led by Dr. Lukaszew, dedicated to study the magnetic properties of artificially patterned magnetic nano-structures.

The Role of Boundary Conditions in Stellar Wind Topology and Hydrodynamics

Student: Althea Moorhead
Advisor: Dr. Jon Bjorkman

Abstract:

Mass loss from luminous early-type stars occurs via a line-driven stellar wind. The accepted model for these winds was developed by Castor, Abbot, & Klein (1975; hereafter CAK). Originally the CAK model treated the star as a point source of radiation; however, close to the star the finite apparent solid angle of the star reduces the radiation force, modifying the mass loss rate (Friend & Abbott 1986; Pauldrach, Puls, & Kudritzki 1986). Friend & Abbott also included the effects of rotation; however, they were unable to perform a systematic study of all possible wind solutions,

owing to the non-linear nature of the wind momentum equation. This permitted a critical point analysis of the CAK wind similar to that used by Parker (1960) to systematically determine all possible outflow solutions. This analysis showed that for a CAK point source wind, there was only one outflow solution with an x-type critical point. However, Bjorkman (1995) did not include the finite disk correction factor nor did he include rotation. In the present study we use Bjorkman's method to obtain the wind topology of rotating winds by adding the centrifugal rotation force and the finite disk correction factor to the CAK wind equation. We present topology plots of the finite disk corrected CAK for varying rotation speeds. After matching the surface density boundary condition (by varying the mass loss eigenvalue), we obtain the mass loss rate as a function of rotation.

The finite-disk CAK equation produces quite varied solution topologies as the rotation rate is increased, eliminating some critical points while creating others. In particular we find that at high rotation rates the inner x-type critical point's existence becomes increasingly sensitive to the mass loss eigenvalue, while new x-type critical points appear at large radii. In addition, the CAK wind equation has two solutions for the velocity, which leads, more or less, to a doubling of the number of critical points (up to 10 total). Most importantly, two x-type critical points were found that satisfied the boundary conditions of finite pressure at the star's surface and zero pressure at infinite distance from the star. This results, for rotation rates between 77% and 79% of the critical rotation rate, in multiple outflow solutions for the star, leading to the possibility of multiple mass loss rates. At 79% of the critical rotation rate, the inner critical point ceases to satisfy the outer boundary condition; however, we postulate that it may still provide a viable condition if the hydrostatic solution jumps discontinuously in y but not in u. Depending on the unknown time-dependent stability of these solutions, we conclude that it may be possible for a star to switch between high and low mass loss states. This effect could explain the notorious variability of Be stars, where it is observed that the wind can switch on and off as a function of time. Similarly, the fact that the outer critical point solutions have lower wind speeds offers the possibility that the outer solution could lead to disk formation, while the inner solution does not. Thus the multiple wind solutions offer a potential mechanism for explaining the occasional disappearance of the disks around Be stars.

We have attempted to determine the time-dependent stability of the wind solutions by using numerical hydrodynamics. Although we are not able to say anything conclusively about the stability of our solutions, our difficulties have led to insight in the arena of boundary conditions. We had previously believed that if the pressure at infinite radius were greater than that pressure determined by the hydrostatic solution, an inflow would result. We have reconsidered that idea, since that pressure is of the order of about ten to the negative six hundred.

Designing a Side-Pumped Planar Fiber Laser

Student: Steve Morgan
Advisors: Brian Bagley and Robert Deck

Abstract:

In broadband communications using optical fibers there exists a need for a source of photons at a wavelength of 1550 nanometers. Ideally, this photon source would be part of an optical integrated circuit and would have sufficient power to guide a signal through the entire circuit and into the transmission fibers. A good source for 1550 nanometer light in an OIC is erbium doped

silicate glass, which can be pumped by a solid-state laser at 980 nanometers. In order to maximize the amount of output from the lasing chamber of erbium doped silicate glass, one must optimize the amount of light coupled into the chamber from the solid-state laser. Since there is a discrepancy on the order of 10^3 in the ratio of sizes between the lasing chamber and the solid-state laser when coupled from the end, it seems logical to attempt to couple the light into the chamber from the side in order to couple more than only 10^{-3} of the incident light. In this REU program, I used BeamPROP, a simulation program, to model one possible circuit design to side-pump a waveguide with 980 nanometer light. The circuit used a grating of tiny holes drilled along the incident side of the lasing chamber to change the k_z vector of the photons, thus coupling some light along the desired axis in the waveguide. The preliminary results yielded about an order of magnitude more light being coupled into the chamber than with the end-pumping method. I believe that these findings merit further investigation, and I will continue to explore this problem at the University of Toledo. This program taught me a great deal about a career in physics research.

The Size Dependence of ERE Properties and the Effects of Photofragmentation On the Size Distribution of SNPs

Student: Lori Schmetzer
Advisor: Adolf Witt

Abstract:

Ever since the ERE was discovered 20 years ago, astronomers have been trying to decipher what causes this extended red emission. To do this they look at the various features of the ERE and try to match them to a suitable carrier. In this paper we explore the size dependence of several of these features, relying on the silicon nanoparticle, or SNP, model. We find that the intrinsic quantum efficiency decreases with size, while the ERE intensity increases with size. Both relationships are roughly linear and follow predictions. We also made size distributions of several radiation environments and explored the effects of photofragmentation on those size distributions. We found that large particles were virtually unaffected, while smaller particles were greatly affected, and almost completely destroyed. Further interpretations of these plots showed that the destruction of SNPs by photofragmentation went as d^{-5}.

Nickel Phosphide as a Copper-Free Back Contact for CdTe-Based Solar Cells

Student: Brian R. Sunderland
Advisor: Alvin D. Compaan

Abstract:

Nickel phosphide was deposited onto CdS/CdTe solar cells, using DC magnetron sputtering, to serve as a back contact. Deposition duration, diffusion temperature, etching procedure, substrate heating, as well as the use of graphite as an inter-facial layer were parameters examined in this study. We found that nickel phosphide can serve as a replacement to Cu-based back contacts, whose tendency to diffuse along grain

boundaries degrading cell efficiency would like to be avoided. Average efficiencies of over 8.6% were achieved and stability shows promise, making Ni_2P an attractive candidate as a Cu-free back contact.

Design Improvements in Data Collection Faraday Cups

Student: Joshua Thomas
Advisor: Thomas Kvale

Abstract:

Reliable detectors are necessary in atomic physics for measuring the true particle beam currents which are used in determining cross sections. The Faraday cup detector is ideally suited for measuring ion beam currents in the range from picoamps to microamps, which are the typical ion beam currents produced by the ion accelerators at the University of Toledo. Previous Faraday cup designs were based on a cylindrically symmetric system, which limited the maximum capturing electron kinetic energy of less than the electric charge times the potential applied to the detector. This research project involved the redesign of the Faraday cup detector by introducing a transverse electric field and thus breaking the cylindrical symmetry. Data using the Faraday cup detectors of both designs are compared and much higher capturing kinetic energies were achieved for the same applied potential for the new design.