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INTRODUCTION

Stony Brook University is proud to host the Research Experiences for Undergraduates (REU) Program in Physics. Sponsored by the National Science Foundation (NSF), this program gives undergraduate students an intensive hands-on research experience and involves them in all phases of the research process. This year, fifteen summer researchers from twelve colleges and universities were selected from a pool of approximately sixty applicants. We were also pleased to have had two visiting undergraduates from Mexico take part in the REU symposium, as well as several Stony Brook students who are currently doing research at the Laser Teaching Center. In carrying out their projects, REU participants worked alongside Stony Brook's faculty, post-docs, graduate students and other undergraduates. The summer activities culminated in a presentation of the students' work in a research symposium and in a written report.

As you read this collection of their abstracts, you will see evidence of their hard work, keen insight and enthusiasm, and be impressed at what they have accomplished in only eight weeks. I have no doubt that these individuals will continue on with successful academic and research careers.

—Erlend Graf, NSF REU Physics Site Director, Stony Brook University

Intererometric Test of Mechanical Stability for a Cavity QED System.

M. Bizarro, Universidad Nacional Autonoma de México;
M. Terraciano, M. Lerotic, L.A. Orozco, Stony Brook University.

Vibrational isolation is very important for most quantum optics experiments. This is the case of cavity Quantum Electrodynamic (QED) system in which small vibrations disturb the experiments. We study the mechanical vibrations of a glass cell that will contain a cavity QED system. We use a Mach-Zender interferometer. One of the arms of the interferometer passes through the glass cell, which can pick up a fluctuating phase change due to the vibrations, with respect to the reference beam, which propagates through the other arm in free space. We produce small changes of the path length in one of the arms applying a voltage to a piezoelectric crystal. We maximize the fringe visibility of the interference signal. We also optimize the signal to noise ratio by placing the interferometer near to the bottom of the fringe. We identify the resonant frequencies of the glass cell apparatus using spectral analysis. The system is very stable for frequencies higher than 1 KHz but at low frequencies there are big resonant frequencies on top of a large spectral density. Present day feedback techniques can control such vibrations in the cavity QED system. This study was supported by NSF Grant No. PHY0097691 and Sociedad Mexicana de Física.

Observing the Sodium Doublet and Laser Diode Mode Structure with a Czerny-Turner Spectrometer.

Doug Broege, John Noé, Harold Metcalf, Laser Teaching Center, Department of Physics and Astronomy, Stony Brook University.

A spectrometer is an instrument that can separate the components of a particular source of light according to wavelength. Spectrometers are vital in optics and atomic physics because the light emitted from a source can tell us a great deal about its inner workings.

My project involved setting up and using a small Czerny-Turner type spectrometer. The spectrometer consists of two 30 cm focal length mirrors, a diffraction grating (1800 lines/mm), and a linear array of 2048 photodiodes. The Czerny-Turner arrangement works by first collimating a divergent beam with one mirror, which directs it towards the diffraction grating. The diffracted light leaving the grating is collected by the second mirror, which focuses it on to the diode array. The Unicode diode array, which was originally intended to analyze laser beam profiles, is extremely useful in this setup because it allows one to view a complete region of a spectrum at once on an oscilloscope. This gives a lot of valuable information with respect to the relative intensities and separation between different wavelengths, especially when these features are changing with time.

One source studied was a sodium vapor lamp. With the help of a 500 micron pinhole, the well-known yellow doublet at 589.0 and 589.6 nm was clearly (although not completely) resolved. We found that the relative intensities of the two peaks changed over time as the lamp warmed up. Another interesting source was a small laser diode similar to a laser pointer, which has been used for many of my experiments on holography. When aligned to the laser's average wavelength, the spectrometer clearly displays each separate mode running in the laser (multimode operation). We were thus able to determine many of this particular laser's characteristics such as mode spacing, the number of modes running at a time, and the time it takes to stabilize at one frequency. Possible future work includes analyzing the mode structure of a 780 nm diode laser used for rubidium spectroscopy, before and after frequency locking.

We would like to thank Dr. Mark Wagshul of Stony Brook Hospital for donating the components of the spectrometer to the Center. This study was supported by NSF and ONR.

Power Law Decay of Phosphorescent Materials.

Jill Chen, John Noé, Harold Metcalf, Laser Teaching Center, Department of Physics and Astronomy, Stony Brook University.

Phosphorescence is the emission of light from "glow-in-the-dark" materials seconds, minutes, hours, or even days after they have been activated by a light source. Phosphorescence has many valuable applications, such as safety signs that don't require electricity, and also has a complex and interesting underlying physics and chemistry related to "triplet states" in solids.

My research involved measuring the delayed light emission from a 6x7 cm sample of commercial phosphorescent film (type B-901) provided by Shannon Luminous Materials, Inc. in Santa Ana, California; it was said to contain "mixed oxides of Al, B, Sr, Eu, and possibly, Hf." After activating the sample with various light sources the greenish-yellow afterglow light was observed over a period of hours with a photodetector and voltmeter interfaced to a computer. The several thousand readings obtained were analyzed and plotted in a spreadsheet program. In these measurements the photodetector was placed directly on top of the sample to get the most sensitivity. In a separate set of measurements I also studied the light intensity as a function of distance from a simulated sample of nearly the same size with constant light output (an electroluminescent nightlight) in order to create an intensity calibration curve.

During the analysis of my initial data, it was discovered that the light emission after about the first minute following activation obeys a power law of the form $L(t) = 1/t^n$, where the exponent n is very close to 1. The graph of such a relationship is a straight line when plotted on a log-log scale. Power laws are known to describe many diverse phenomena in science, from statistics (the Pareto curve) to physics (1/f noise), but the underlying reason a power law applies in this case isn't as yet understood

More recently I have collected a decay curve over a much longer period of time (18 hours versus 2 hours) for the same sample after activation in sunlight instead of incandescent light. Readings were still taken at one second intervals, but after the first 10 seconds they were averaged in the spreadsheet over periods of 10, 100, or 1000 seconds before plotting. A computer program is being written to do this averaging automatically during the data taking. Both the light versus distance and light versus time plots level off at small distance or small time in a similar way, and both can be well described by "modified hyperbolic curves" of the form $1/(a+x^n)$ with $n = 2$ or ~ 1, respectively.

Future plans include observing the decay with the sample held at a different temperature, to see if this changes the exponent n in the power law.

This study was supported by NSF and ONR.

Neutrino emissivities from the plasma process in supernovae.

Constantinos Constantinou and Madappa Prakash, Department of Physics and Astronomy, Stony Brook University.

Neutrino emission from hot dense matter is an important aspect of supernovae and the formation of neutron stars. We focused on the plasma process for neutrino production, which stems from the decay of photons and plasmons into neutrino pairs. In the conditions encountered in supernovae this process could dominate other sources of neutrinos. The beginning point for our calculations is the calculation of the dispersion relation, which describes the effective mass of photons and plasmons. This was investigated in the classical limit in which the plasma is nondegenerate and nonrelativistic. The degenerate (low temperature) limit and the relativistic (high temperature or high density) limit were also considered.

Quantum Adiabatic Geometries.

Evan Fink, Massachusetts Institute of Technology; Alfred Goldhaber, C.N. Yang Institute for Theoretical Physics, Stony Brook University.

Powerful approximation techniques can be employed to describe systems which have parameters that vary adiabatically, or slowly. An appropriate analogy is with special relativity, where dynamical terms can be written in terms of a power series in velocity; when the velocity is slow (i.e., non-relativistic), a truncation of this power series at second order gives us the familiar Newtonian mechanics. This approximation is very simple, and clearly consistent with itself. Similarly, adiabatic approximations that consider only terms up to second order in velocity can be used, to the same effect. To obtain a consistent approximation, one needs to include certain effects that can be understood from the geometry of parameter space. These include a scalar potential (which can be obtained by averaging fast variables present in the approximation) and Berry's vector potential (which can be understood as the expression of an induced "magnetic" force). To obtain a consistent approximation, we must include one more effect: induced inertia, which has been overlooked in many recent works. A general method for computing this induced inertia has been developed. The induced inertia can then be used to properly calculate the effects mentioned above, yielding the desired consistent approximation. This approximation, when applied to the case of a neutral particle with spin in an adiabatically varying magnetic field, is shown to give a result in a simple manner, that had previously been found by a far more involved computation.
This study was supported by NSF Grant No. Phy 99-12312.

Quantum Efficiency of Cesium Iodide on Metallic Substrates.

Philip Frankel, State University of New York at Binghamton; Bob Azmoun, Thomas Hemmick, Department of Physics and Astronomy, Stony Brook University.

The following study attempts to ascertain the quantum efficiency of prepared cesium iodide photocathodes. CsI coated photo cathodes, due to their high light sensitivity, are currently being considered for use with a hadron blind detector at Brookhaven National Laboratory's PHENIX experiment. The preparation of the cathodes involved cleaning a vacuum chamber, coating the inside surface with a thin layer of CsI, and pumping down to 5×10^{-8} torr. Crystals of CsI were placed in a molybdenum boat and slowly evaporated onto substrates of aluminum, and copper plated with nickel and gold. A quartz crystal oscillator monitored the thickness of the deposited Cesium. Immediately following the deposition of approximately .75 microns of cesium, the cathodes were sealed in small evacuated desiccators and transported to Brookhaven Labs for quantum efficiency measurements. The quantum efficiency of the samples, defined as the ratio of the photo-flux incident upon the cathodes to the produced photoelectron current, was measured using a VUV spectrometer kept in a vacuum of 2×10^{-4} torr. A deuterium lamp was used to generate light of wavelengths 110 to 190 nanometers. Photomultiplier tubes were used to determine the flux incident upon the sample cathodes while an ammeter monitored the photoelectric current. Quantum efficiencies of up to 68% were observed for light of 120 nanometers, and fell off to 20% at 170 nanometers. Measurements of samples stored in pumped vessels for one week indicated quantum efficiency losses of 35%. This study was supported in part by the National Science Foundation.

The Effect of Binaries on the Distance Modulus of NGC 1866.

K. Hinterbichler, Arizona State University; Deane Peterson, Department of Physics and Astronomy, Stony Brook University.

Walker et al. use the main sequence fitting procedure to link the distance of NGC 1866 in the LMC to the Hipparcos determination of the distance for the Hyades cluster. They construct a fiducial line for the NGC 1866 main sequence by looking for the maximum in the V-I histogram for each bin of visual magnitude. The Hyades data were filtered against binaries but the NGC 1866 data were not, leading us to believe that this discrepancy may have an effect on the resulting fiducial line as they derive it. Consequently, we have written a program to model star clusters to determine what effect binary systems have on their fitting procedure. There are a number of effects that come into play with this fitting procedure, and the bin sizes must be kept small in order to minimize these effects. After correcting for interstellar reddening and for differences in composition between the clusters, they obtain a distance modulus of 18.35 ± 0.05 mag for NGC 1866. We see a difference in vertical offsets of 0.2 ± 0.1 mag, or an offset of 10% in distance ± 5% in the location of the deduced main sequence when binaries are added and removed, indicating that the distance modulus may need to be corrected accordingly. This study was supported by NSF Grant No. Phy 99-12312.

Design and Implementation of a Data Acquisition System for the PHENIX "Canary Chamber." Rita Kalra, Thomas Hemmick, Boris Komkov, Yuriy Komkov, Victor Riabov, Felix Matathias, Sergey Butsyk, Department of Physics and Astronomy, Stony Brook University.

The PHENIX Experiment is one of the two large Nuclear Interaction Experiments at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab. The main tracking detectors of the experiment, two large Drift Chambers, were designed and constructed by the Petersburg Nuclear Physics Institute, Russia, in collaboration with the Physics Department of The State University of New York at Stony Brook. The Monitoring ("Canary") Chamber is an additional, external device to the Drift Chambers that serves the purpose of measuring and monitoring the drift velocity of electrons inside the two Drift Chambers with very high accuracy. The Canary Chamber is filled with the same gas that enters or directly exits the Drift Chambers. Electrons emitted by a β-source create an ionization trail passing through the gas, which drifts towards an anode. The Canary Chamber then measures the average time it takes for the electrons to drift a known distance from the ionization region to the anode. My task this summer was to program the data acquisition system for the Canary Chamber, which included controlling the high voltage to vary electric field, controlling the valves that send gas into the Chamber, and accumulating and analyzing data. This was accomplished by using the CVI/LabWindows Graphical User Interface software in conjunction with a National Instruments PCI-6024E Multifunction Data Acquisition Card. Event-driven programming was determined to be the most practical means of operating the Chamber, since it provides more control of system events by allowing interaction between user and program through a graphical user interface, in the case that manual operation of the chamber is needed. The program involves the use of a state machine and main timer that executes functions according to the global state of the system. These states include waiting for the gas to clear after the valves just changed, waiting for voltage to stabilize, and waiting for data to accumulate. After the program was written, it was tested using a relay switch board, a DC Voltage source and a Voltmeter to verify that the voltage and gas control of the program were working correctly, and it was proven to work as expected. Data acquisition through the use of communication protocol ARCNET is still in progress. This project was supported by NSF Grant No. Phy 99-12312.

Stabilization and Narrowing of a Laser Diode by External Seeding.

Guillermo M. Mallén-Ornelas, Universidad Iberoamericana, José Jiménez-Mier, L. A. Orozco, Stony Brook University.

We present an injection locked laser diode. We inject 0.3 mW of light from an MBR110 Coherent Titanium Sapphire laser into a Sanyo DL7140 free running diode laser. We monitor the laser diode threshold current to optimize the seeding and follow its lowering up to the point where the laser remains single mode. We analyze the spectrum of the laser diode with a Fabry-Perot interferometer. When there is seeding, the slave laser changes its frequency to that of the master laser. We lock the 780 nm Ti:Sapph laser to an atomic resonance of Rb vapor cell to determine if the slave laser is following the master laser. For a given temperature of the laser diode there is at least one current for which the seeding slaves the laser. The frequency of the slave laser is unstable as monitored by the Rb fluorescence. Changes in the diode laser current and the temperature help the stability, but mechanical vibrations disturb the performance as well. We get more than 60 mW of narrowed power available for further experiments.
This work was supported by Universidad Iberoamericana, NSF grant no. phy0098793 and Sociedad Mexicana de Física.

Sum Frequency Generation of Near-Ultraviolet Light for the Excitation of Meta-Stable Helium.

José Mawyin, John Noé, Harold Metcalf, Laser Teaching Center, Department of Physics and Astronomy, Stony Brook University.

The goal of my project is to find the most efficient way to generate near-ultraviolet light at 389 nanometers. This wavelength is of great interest to the Metcalf Research Group for research related to highly-excited states in helium. The method of choice for the generation of light at this wavelength is Sum Frequency Generation (SFG), which is one of the many applications of non-linear optics.

Non-linear optics is not a new field in physics, and even Maxwell in the mid-nineteenth century was aware that his equations defining electro-magnetic fields could be non-linear. But it was until the advent of lasers, when the necessary density of the electric field could be achieved, that it was possible to study non-linear phenomena. Non-linear effects arise from the equation that defines the polarization density as a function of the electric field, which can be seen as a Taylor expansion with increasing higher orders terms of the electric field multiplied by a diminishing factor, specific to each type of medium. All dielectric media can exhibit non-linear behavior. But only when the electric field amplitude reaches the magnitude of the inner-atomic field can we easily observe and use it.

There are many applications of non-linear behavior, such as: Second Harmonic Generation, Parametric Amplification, Frequency Up and Down Conversion, Sum and Difference Frequency Generation, etc. Sum Frequency Generation can be easily visualized as the absorption by an atom of two photons of frequency f_1 and f_2 followed by the emission of a photon with the frequency $f_3 = f_1 + f_2$. The medium that we are proposing to use for this process is a non-linear crystal such as BBO (Beta-Barium Borate) or LBO (Lithium Triborate). These crystals were considered because they are the most efficient at the wavelengths that we will use. The light sources that we will use are a Verdi laser at 532 nanometers with a power output of 10 Watts and a diode laser at 1447 nanometers with $P > 200$ milli-Watts. The diode laser will be connected to a rare-earth fiber amplifier to increase its power to > 1 Watt. These two beams will then be phase-matched -- a process which maximizes the interaction of the beams and the crystal -- and directed through the crystal.

At this point, we will have to deal with some new problems, such as stabilizing the infrared diode laser (we are proposing to use a fiber Bragg grating for this), maximizing the efficiency of the fiber amplifier, and correctly phase-matching the optical fields within the crystal. This latter task is necessary to reduce the destructive interference of the produced light of frequency f_3 which has been created at different points along the beam path. We are expecting to finish addressing the inquiries about the equipment and materials that will be needed in a few weeks. As soon as we receive these, we will begin work on integrating all the parts and then on optimizing the process.

This research was supported by NSF, ONR and AGEP.

Further Development of the Fermi-Pasta-Ulam Experiment.

J. E. McElhenny, University of Scranton; P. B. Allen, Department of Physics and Astronomy, Stony Brook University.

In a chain of 64 particles each interacting anharmonically with their two closest neighbors, one expects that the chain would thermalize. Fermi, Pasta, and Ulam tried to study the rate at which the chain thermalized, but it turned out that the chain did not show a tendency towards thermalization. We modified the system from being a string with fixed ends to a ring. Also, we changed the force between the particles from quadratically non-linear to the Toda potential e^x-1-x. Finally, we used a combination of two Toda potentials and plan to compare the results. The experiment has not yet been completed, but the preliminary results are contained in this paper. This study was supported by NSF Grant No. Phy 99-12312.

An Apparatus for Demonstrating Gradient Index Optical Effects.
Jennifer Marie Nierer, John Noé and Harold Metcalf, Laser Teaching Center,
Department of Physics and Astronomy, Stony Brook University.

Refraction is the well known optical effect in which light rays moving from one medium to another bend towards or away from a line perpendicular to the boundary between the two media. The amount of bending is given by Snell's law, which involves the velocity of light in the two media through the index of refraction n = c/v. Refraction is obviously important in lens and other optical devices, but also has many other less well-known applications, such as measuring the concentration of chemical solutions, urine analysis, etc. Materials with continuously-varying index of refraction are especially fascinating and have many important applications as well, such as Gradient Index (GRIN) lenses and GRIN optical fibers. GRIN phenomena also occur in nature in mirages and other atmospheric effects.

My work in the Laser Teaching Center has involved creating and studying a device for demonstrating gradient-index optical effects. It consists of a small fishtank which is set up with equal portions of Karo corn syrup (n=1.47) and water (n=1.33). Initially the horizontal boundary between the two media is rather sharply defined, and a laser light beam makes a sharp bend at the transition, according to Snell's law. As time goes by, the boundary becomes more and more diffuse, so that the index of refraction varies smoothly from the top to the bottom of the tank. As a result of the index gradient a laser beam crossing the tank bends in a dramatic downwards arc which has an approximately parabolic shape.

One goal of the project was to measure the evolution of the index profile mixture and the resulting changes to the optical trajectory over a period of weeks. After considering several possible methods involving total internal reflection I decided to use the optical activity of the corn syrup as a measure of the index n. The rotation was measured as a function of depth in the tank using a mounted laser pointer and a rotating polarizer. I hope to use this information to predict the observed trajectories of the light, which were recorded in a digital camera.

Besides my tank studies much of my time was spent in developing a web-based resource about refraction and related optics topics. It includes many excellent web links, some of which describe experiments that are simple enough to be performed in a kitchen with only minimal previous background knowledge in science. It is hoped that this web-resource will inspire many others to attempt their own research projects.

This research was supported by NSF Grant No. Phy 99-12312.

Detecting and Measuring Properties of Cosmic Ray Muons.

John Schaub, New Mexico State University; Sioan Zohar, Yeshiva University; Bjorg Larson, Michael Rijssenbeek, Department of Physics and Astronomy, Stony Brook University.

The Stony Brook High Energy group is developing a curriculum for high school teachers who want to introduce their students to principles of, and experiments in, particle physics. These experiments must be checked to assure that they are simple, foolproof and inexpensive enough and produce accurate results consistently enough to be used in a high school classroom. We tested two detection methods, both focusing on cosmic radiation particles, especially muons; this radiation passes through everywhere at all times and is therefore the most readily available source of particles. The first method used aluminum covered scintillator paddles with photomultiplier tubes to detect particles. With these we measured the average cosmic radiation flux, from which we calculated that the annual dosage one receives from cosmic radiation is in the same range as that from other naturally occurring radiation. We determined the rate of radiation as function of zenith angle, and, approximately, the portion of this radiation that consists of muons. We measured the muons' speeds and lifetimes. For the second detection method we built a cloud chamber. Calculated from the previously measured flux we determined the size that would show approximately one cosmic ray particle per second. We selected our materials based on cost and availability. This study was supported by NSF Grant No. Phy 99-12312.

Developing New Experiments and Apparatus for Determining Young's Modulus and the Coefficient of Linear Thermal Expansion for Upper-Level Undergraduate Physics Labs.

J. J. Sears, University of Northern Colorado; E. H. Graf, Department of Physics and Astronomy, Stony Brook University.

The focus of my research was to develop new and more precise methods of determining both Young's modulus and the coefficient of linear thermal expansion. Traditionally, these experiments are done with an optical lever to measure changes in length. However, we wanted to take advantage of a Michelson interferometer's ability to detect changes in length as small as a fraction of the wavelength of light. This is done by using a piece of plexiglass mounted on a swivel and placing it in the path of the laser beam on the Michelson interferometer. A wire is attached to the lever arm of the plexiglass, so that when the wire stretches, the plexiglass tilts. The tilting of the plexiglass changes the optical path length of one of the interferometer beams, and fringe shifts are observed that correspond to the change in length of the wire. In determining Young's modulus, the stretching of the wire is accomplished by slowly increasing the weight attached to the lever arm. When determining the coefficient of linear thermal expansion, the wire expands when heated by an electrical current. Once the change in length of the wire is known, either Young's modulus or the coefficient of linear thermal expansion can easily be determined for the particular experiment. The values I obtained were in good agreement with published standards. This study was supported by NSF Grant No. Phy 99-12312.

Operating Modes of Various Helium-Neon Lasers.

Owen P. Smith, Worcester Polytechnic Institute; John Noé and Harold Metcalf, Laser Teaching Center, Department of Physics and Astronomy, Stony Brook University.

The characteristics of longitudinal and transverse modes in several types of red helium-neon (He-Ne) lasers were studied. The lasers studied included various surplus and commercial units ranging from a few mW to nominally 25 mW, plus an open frame laser with a Brewster window and one adjustable mirror.

The longitudinal modes of a laser are the different wavelengths of light that can be accommodated in the laser cavity and amplified by the gain medium. The mode spacing Δf is given by $c/(2L)$, where L is the length of the cavity. For He-Ne lasers Δf is typically a few hundred MHz to a GHz. To study these the lasers were aligned with a photo-detector and a polarizer was placed in the beam path. The effects of the polarizer on the intensity vs. time profile were examined and several different characteristics of the laser modes were studied. In the course of these experiments it was determined that the nominal 25 mW laser was probably defective since it was operating at only 15 mW and was exhibiting wild fluctuations in the MHz frequency range.

Transverse modes were studied in the open-frame laser, which was built around a Melles Griot 05-LHB-570 tube with nominal ouput power 4 mW. This tube has an unusually wide bore (2 mm vs. 1 mm or less), which makes it easy to create a variety of transverse modes by tilting the mirrors or introducing small objects into the laser cavity. Using a flat external mirror in combination with the R = 60 cm internal mirror of the laser tube, it was possible to achieve stable operation at a cavity length of 55 cm. Transverse modes with index numbers as high as 3 or 4 were observed, as well as various superpositions of transverse modes.

We wish to thank John Brandenberger of Lawrence University for the metal frame used for the open laser, and Sam Goldwasser for invaluable advice and assistance. This study was supported by NSF Grant No. Phy 99-12312.

Testing Forward-Hadron Calorimeters using Cosmic Ray Muons.

Raymond T.R. Stantz-Solano, Florida Atlantic University, Boca Raton, FL; Stephen Johnson, Lawrence Livermore National Laboratory, Livermore, CA; Thomas Hemmick, Stony Brook University, Stony Brook, NY.

It is theorized that during the first few microseconds after the big bang there existed a phase of nuclear matter called *quark-gluon plasma* (*QGP*) in which the composites of hadrons, quarks and gluons, were no longer confined within nucleons but were deconfined. One of the tasks of *RHIC* (*Relativistic Heavy Ion Collider*) is to simulate the conditions these first microseconds after the birth of the universe and create a quark-gluon plasma in the laboratory. This task is executed by colliding beams of heavy nuclei (ions) into each other. Because such collisions produce complicated events involving thousands of particles, the RHIC program seeks to study and compare basic proton-proton and proton-nucleus collisions as a baseline study of cold nuclear matter. By measuring *forward* or *grey protons*, the "centrality" of proton-nucleus collisions can be determined, thus making the comparisons to nucleus-nucleus collisions more efficient. To detect these *forward hadrons*, a specific type of particle detector called a *calorimeter* is utilized. The PHENIX experiment proposes to employ a calorimeter that was decommissioned from an earlier project (E864 at *Brookhaven National Laboratory*). Our main purpose this summer was to test these calorimeter modules and determine if there had been any serious corruption in their performance since they were decommissioned. The original photomultiplier tubes were reconnected to the modules and a cosmic ray test stand was constructed. To track the responses of the modules and tubes to the muons, a PHENIX standard CAMAC and VME based data acquisition system was used as well as a data analysis software package (ROOT). To measure the response of the modules, the attenuation lengths pulse were measured. The results of this study are consistent with the E864 results of past experiments thus allowing the forward hadron calorimeters to be instrumented in the upcoming December run at RHIC. This study was supported by NSF Grant No. PHY 99-12312.

Electric-Field Effects on Two-Dimensional Electron Gases.

C.Y. Woo, F. Camino, E.E. Mendez, Department of Physics and Astronomy, Stony Brook University.

Although the heating effect of an electric field on a two-dimensional electron gas (2DEG) has been extensively studied, little attention has been paid to its effects on various electron scattering mechanisms. In our study, we have observed non-linearities in low-temperature (1.5K<T<4.2K) the current-voltage characteristics of high- and low-mobility 2DEGs created in GaAs/AlGaAs and low-mobility InGaAs/InAlAs heterostructures. Electron heating is revealed by the electric-field dependence of the amplitude of the Shubnikov de Haas oscillations in the resistivity, from which we have determined the electron temperature T_e (1.5K<T_e<6K). We have also measured the temperature dependence of the resistivity in the low-current limit from 4K to 90K; by comparing the change in mobility due to electron temperature or lattice temperature, we could, in principle, isolate the contribution of acoustic phonon scattering in the 1.5K to 6K range. We have found that for the high-mobility sample, the phonon contribution below 4K obtained through this method agrees with the value calculated from the T dependence of mobility in the 10K to 50K range, where the acoustic phonon scattering dominates. In contrast, in the low-mobility samples, we have found a large discrepancy between the two determinations. This discrepancy suggests that the electric field, in addition to heating, affects the electron scattering mechanisms, namely, the interactions with phonons and ionized impurities. The reason why this discrepancy is only visible in low-mobility samples is not yet understood and needs to be further studied. This project is supported by NSF Grant No. Phy 99-12312.

Dynamics of an Underpowered Helium-Neon Laser.

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The operating behavior of an underpowered helium-neon (He-Ne) laser was studied to determine whether there may or may not exist a chaotic aspect to the phenomena. Chaotic behavior in lasers has been noted in numerous systems such as those with modulated or conjugated feedback and in lasers with nonlinear open cavity resonators. The current study was motivated by concepts outlined by researchers at Moravian College (http://home.moravian.edu/public/phys/research/research.html) regarding the observation of seemingly aperiodic behavior in underpowered gas lasers.

A He-Ne laser usually operates in a continuous manner, but when the voltage and current supplied to the gas-discharge tube is limited the continuous operation ceases. For certain values of current and voltage the laser goes into a flickering state. Pulse widths we observed ranged from around a quarter to a half of a millisecond while the pulse spacing ranged from around ten to twenty milliseconds. An apparatus was developed to collect data that could be used in a time series analysis to determine whether there indeed exists chaotic behavior. The relevant data was the time at which each of the pulses took place. This allowed for the comparison of the duration between pulses corresponding to each pulse. This data was taken through the use of a computer's parallel port that monitored a function generator which was triggered by a photo-detector. A He-Ne laser, which was controlled by a variable DC power supply, was observed by the photodetector. Programs written in C++ were used to monitor the parallel port status and collect and manipulate the data into a set of times between pulses.

It was intended that our observations would be compared with those of researchers at Moravian College. Currently there are obstacles in completing the analysis due to problems in triggering the pulse generator and developing a program that regulates the length of time between the iterates which query the status of the parallel port. Further studies should take the Fourier transform of the pulse spacing values in order to find a primary frequency to be used in the production of a Poincari section. This may then be utilized to determine whether there exists an attractor of extended structure, which would be necessary for there to be chaos.

This study was supported by NSF Grant No. Phy 99-12312.

Research in Brown Dwarfs and Young Stars.

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I worked on two projects during my time here, both of which were small parts of ongoing research in astronomy. The first project involved brown dwarfs, sub-stellar objects which became detectable only in the last decade. According to theory, everything about the life of a star should be determined by its mass. Below 0.075 solar masses, nuclear fusion cannot occur, and brown dwarfs glow as their gravitational potential energy is converted to heat. It is the goal of Michal Simon and others to measure their masses in order to compare them with theoretical values. I wrote a program in the IDL programming language which predicted the locations of binaries in their orbits. I also adapted a program to predict the velocities of binaries. I tested this on the brown dwarf binary Gliese 569B and ran the program for several newly discovered binaries. The purpose of this was to aid in the observation of Gliese 569B and to see whether or not the differences in velocity would be observable for the other systems.

My second project involved reducing the data taken from an infrared spectroscopy survey of various young stars. The purpose of this work was to study the composition of the interstellar disks of these young stars. Similar to the visible spectrum, different elements emit and absorb different wavelengths on the infrared. By analysing the infrared radiation which reaches earth from a given star, the composition of matter between the star and earth may be determined. These studies were supported by NSF Grant No. Phy 99-12312.

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