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CREATING AN INTERACTIVE PHYSICS DEMONSTRATION USING JAVA.

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When learning physics, it is helpful to have a visual aide or hands-on experiment to assist in the learning process. Using Java, one can create simulations and demonstrations (called applets) that can be accessed on the web. This summer, I began work on an applet used to study the dynamics of elementary particles with a hydrogen bubble chamber photograph. In the photo, a beam of pions hits a hydrogen (hence, proton) target. The interaction produces two neutral particles, a K_0 and a Λ_0, which decay into two charged particles each. The charged particles ionize the liquid hydrogen and produce bubble trails, while a magnetic field directed out of the photo bends them into helical paths, enabling the particles' momentum to be determined. The momentum is proportional to the path radius of each particle, which is calculated by measuring the arc of path. Then, by calculating the particle's energy, the laws of conservation of momentum and energy can be verified. To translate this into a workable Java applet, track measurements will be made by clicking points on the photo and calculations will be made by clicking buttons. The user chooses the magnitude of the B field, which tracks to measure first, and the points used to calculate the path radius. Java code was written for the calculations involved in the demo and construction began on the layout for the user interface and the necessary components. As this is a complicated project that will extend into 2001, the source code for the applet only reached preliminary stages and will be further developed in the fall. This project was supported by NSF Grant No. PHY99-12312.

CONTINUING CONSTRUCTION AND PRELIMINARY DATA ANALYSIS OF THE PHENIX PAD CHAMBERS.

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The PHENIX project is a multi-element particle detector intended for the study of gold-gold nuclear collisions at the Relativistic Heavy Ion Collider (RHIC) of Brookhaven National Laboratory. The ultimate goal of the experiment is to create, identify, and study quark-gluon plasma, an extremely dense and hot phase of matter that existed during the first few microseconds of the universe. PHENIX will help discern between multiple competing theoretical predictions for the thermodynamic properties of this phase of matter. This project focused on the PHENIX Pad Chambers, a set of multiwire proportional chambers designed to reconstruct the trajectories of charged ionizing particles originating at the collision point. The chambers required mechanical construction, including drilling, gluing components soldering wires and attaching jumper cables, and cleaning. Furthermore, some tests were required: each chamber was tested for gas leakage rates and for the capacity to hold operational voltage (up to 2000V) without drawing current (the absence of short-circuits). The chambers that were tested within this project showed acceptable gas leak rates but exhibited difficulties with holding high voltage, which we concluded resulted from faulty epoxy used to glue together some of the chambers' components. A combination of gas curing and cleaning resolved the high voltage problems. Several of the pad chambers were already in place in the PHENIX detector at the time of this project and preliminary collision data was recorded with them. The data was analyzed using the ROOT plotting program, particularly for the determination of the collision point (the vertex) with the intent of calibrating the geometry of the pad chambers. This study was supported by NSF Grant No. PHY 99-12312.

CONSTRUCTION OF PAD CHAMBERS FOR PHENIX EXPERIMENTAL FACILITY AT BROOKHAVEN NATIONAL LAB. PRELIMINARY DATA ANALYSIS OF AU + AU COLLISIONS. Tim McIver, University of Massachusetts at Lowell, Thomas Hemmick, State University of New York at Stony Brook, and Michael Sivertz, Brookhaven National Lab.
The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab is designed to collide gold ions (Au + Au) at high velocity (gamma = 70). Phenix (Pioneering High Energy Nuclear Ion eXperiment) is a multi-detector experimental facility at RHIC. One of the detector sub-systems consists of a set of multi-wire proportional chambers (MWPC's) called pad chambers. The chambers are designed to detect charged particles that are ejected from the Au + Au collision. With this data the trajectories of these charged particles can be reconstructed. This information can then be used for particle identification. The ultimate goal of the RHIC facility is to collide gold ions with enough energy to create a quark-gluon plasma (QGP). The QGP is a state of matter that existed for a fraction of a second after the Big Bang. The construction of the pad chambers consisted of gluing and soldering very thin wires to a fiberglass frame. The wires were enclosed in this frame by gluing and bolting other fiberglass components to the frame. Testing the chambers included measurement of gas leak rates form the chambers and high voltage tests. Data from the first collisions at RHIC was also analyzed using the ROOT data analysis package. This study was supported by NSF Grant No. PHY 99-12312.

JAVA SOFTWARE FOR THE PHENIX EXPERIMENT. Josh King, Virginia Tech and Thomas K. Hemmick, State University of New York at Stony Brook.
The PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC), located at Brookhaven National Lab (BNL), aims to recreate and detect the quark-gluon plasma, a state of matter that has not existed since the nanoseconds immediately following the Big Bang. A project the size of PHENIX requires a fair amount of computing, including data analysis and data collection. The data acquisition system at PHENIX is essentially a large distributed computing endeavor involving many processors working in tandem and communicating via the CORBA protocol. The object-oriented language Java is particularly suitable as a graphical user interface in distributed computing due to its portability and inherent understanding of CORBA. The detector is controlled remotely via Arcnet, which allows the transfer of instructions and messages to and from the detector. Throughout the current summer, the Java software that delivers run parameters to the Drift Chamber detector has been updated. The presentation will include a brief introduction to PHENIX, a sympathy-inducing story of the trials and tribulations of self-taught Java, an explanation of the Arcnet architecture, an overview of specific software updates, and a summary of planned updates. This study was supported by NSF Grant No. PHY99-12312.

A SECOND GENERATION MAGNETO OPTIC TRAP (MOT) FOR FRANCIUM.
Ignacio Gallardo, Universidad Nacional Autonoma de México, Seth Aubin, Luis A. Orozco and Gene D. Sprouse, State University of New York at Stony Brook.

The spectroscopy of francium, the heaviest unstable alkali element, can allow us to study parity non- conservation in atoms. However, we first have to produce and capture them into a MOT. The trap needs two forces to stop the atoms (around a million), a velocity dependent force, (VDF) and a position dependent force, (PDF). We have worked on the preparation of the laser, to run the experiment in the second-generation francium trap. The laser provides the energy, the system will need to slow down the atoms (with the VDF), and aim them towards the center of the trap (with the PDF). Furthermore, the PDF needs a magnetic field gradient, created by two parallel coils with current in opposite directions. We have iterated between design and calculations due to the many constraints of the trap. We have done the theoretical analytical and computational calculations of the chosen arrangement and designed a way to build it. We have constructed the coils and made a real size model of the trap, in order to fit all the inner elements before we use the real one. We will discuss the precise experimental setup, the difficulties to fit all the elements inside the trap and we will show some tests results done on the built coils. Work supported by SMF, UNAM, and NSF.

FIELD INTENSITY CORRELATION. Adrián Pérez Galván, Universidad Iberoamericana, Matthew L. Terraciano, and Luis A. Orozco, State University of New York at Stony Brook.

A field intensity correlation function of light gives information on its spatial and time properties. Such correlation functions are conditional measurements of the field given an intensity. This property has been used to measure the field of a single photon [1]. We have studied the classical correlation between the electric field and the intensity of a beam of light. We employed a Mach-Zehnder interferometer for the measurements. One arm of the interferometer has the time and space variation elements. The fluctuations in time were made by a liquid crystal and a slide with variable alternation made the fluctuations in space. This same arm has a beam splitter to reflect a small fraction of the light to an intensity detector. The other arm has a Brewster plate mounted on a motor for adjustment of the phase of the interferometer. The interferometer operates with maximum visibility and with its phase actively locked using a digital feedback system. We will discuss the apparatus and the results of our measurements. Work supported by Universidad Iberoamericana, S.M.F. and N.S.F.

SINGLE BUBBLE SONOLUMINESCENCE. Rachel Ruch, San Francisco State University, John Noe and Harold Metcalf, State University of New York at Stony Brook.

Single bubble sonoluminescence (SBSL) is the process of creating flashes of light using ultrasonic sound waves. It is a phenomenon of considerable current interest due to the extremely high temperatures reached (above 10,000 K) and the mysteries still shrouding the details of the mechanism. SBSL is brought about by injecting a gas bubble into a flask of liquid, typically degassed water, that is vibrating at its resonance of ~26 kHz. Two piezoelectric transducers (PZTs) on opposite sides of the flask create the necessary intense standing wave. The bubble is attracted to the vibrational node at the center of the flask, where it repeatedly expands and contracts due to the changing sound pressure in the surrounding liquid. The rapid collapse of the bubble causes it to emit photons, which appear to peak in the ultra-violet. Achieving SBSL requires ~1000 peak volts AC across the PZTs. This high voltage can be attained with the use of a tuned LRC circuit in which the PZT acts as an electrical capacitor. Up until now our efforts have been concentrated on constructing and tuning this circuit and developing a suitable amplifier to drive it. Now that all the right components are in place, we are in the process of searching for the light emitted during SBSL. This study was supported by NSF Grant No. PHY 99-12312.

AN EXTENDED CAVITY TUNABLE DIODE LASER. Petr Liska, Bridgewater State College, Harold Metcalf and John Noe, State University of New York at Stony Brook.
A diverse and vast amount of experiments at the forefront of experimental physics typically use diode lasers as an integral part of their arrangement. However, researchers who use unmodified commercially available diode lasers run into several complications. The laser diode that is purchased is often not of the same wavelength as is advertised; thus the researcher's desired wavelength is not met. Because the semiconductor has such a short external cavity, it is very sensitive to the injection current, changes in room temperature, and has a large linewidth making it harder to tune. To obtain a finely tuned diode laser, temperature and current controlling of the diode laser are used in conjunction with an extended semiconductor cavity. The wavelength may vary by approximately 2.5 nanometers every 10 degrees Celsius. This is achieved by mounting the hermetically sealed assembly atop a thermoelectric cooler, which uses the Peltier effect. Furthermore, the variation of the injection current may be used as an additional control for the wavelength output of the diode. The power range of 70 mW as controlled by the injection current adjusts the wavelength by a span of only 4 nanometers. The extended cavity consists of a diffraction grating adhered to a mirror mount and is used for grating feedback. That in turn is used to reduce the linewidth sufficiently enough in order to provide much better tunability. In the next three weeks, the tunable diode laser will be specifically applied to research in the areas of Second Harmonic Generation in a PPLN Crystal and Saturated Rubidium Spectroscopy. This study was supported in part by NSF grant PHY99-12312.

TEST-BED SYSTEM FOR TRACK FITTING CARD OF RUN II AT D0. Jahred Adelman, Brown University and John Hobbs, State University of New York at Stony Brook.
When the D0 experiment at Fermilab begins its second run this spring, it will be producing significantly larger numbers of proton-antiproton collisions than occurred during the first run. In order to utilize this enhanced luminosity, the trigger system for the detector needs to be upgraded so that only the most interesting events taking place in the collider are recorded. Included in this upgrade is a trigger device (STT) for the silicon microstrip tracker (SMT). One component of the STT is a track-fitting card (TFC) that fits a particle trajectory to a series of hits in the SMT. As soon as it has been designed and fabricated, the TFC will need to be tested to ensure that all its registers and data lines are working correctly. Instead of waiting for the TFC to be created to start a testing system, a PCI Linux driver was written in the C programming language in advance of the board's creation. A program was written to utilize this driver and test as much of the TFC as possible. Complicating the process was the absence of the actual TFC board to test the driver. Therefore, a digital PCI I/O board was used at the beginning of the programming to ensure that a viable driver could be written. Additionally, the I/O board was used after the driver was written to ensure that the program that tests the TFC was also working. The test-bed system is currently completed, and awaits the arrival of the TFC before it is installed as part of the STT. This study was supported by NSF Grant No. PHY 99-12312.

DESIGN AND CONSTRUCTION OF A CO_2 LASER. Patrick Bloom, University of Texas at Austin, John Wilson, Kevin Schultz, and Peter Koch, State University of New York at Stony Brook.

The CO_2 laser has grown dramatically in popularity and functionality since its inception in 1964. The CO_2 laser is versatile, cheap, and simple to operate. Its maximum of 20% efficiency is by far superior to other lasers. The CO_2 laser can be tuned to one of several wavelengths between 9.16 and

10.91 μm. The physical processes of a CO_2 laser are similar to those of other lasers. An applied voltage pumps the discharge with electrical energy causing a population inversion. A standing wave in the resonant optical cavity provides the electromagnetic radiation at the proper frequency for stimulated emission in phase, identically polarized, and in the same direction as the electromagnetic radiation. In the CO_2 laser the emission comes from a transition between two rotational-vibrational levels. The laser tube has a transparent Brewster flat in the positive column in order to produce light that is polarized in a known direction. The laser tube is surrounded by a water jacket that carries away heat in order to maintain a temperature more conducive to lasing. In addition to CO_2, the laser tube contains He, for its high thermal conductivity and propensity for heat transport, H_2O, to prevent the dissociation of CO_2 into C and O, Xe, to lower the average electron energy in the tube to a more useful value, and N_2, to channel energy into a vibrational-rotational level and help the population inversion. The lasing wavelength is selected with a reflecting diffraction grating in the Littrow arrangement. Frequency stabilization is achieved with a piezo-electronic transducer in a continuous feedback loop responding to an opto-galvanic signal. This study was supported by NSF Grant No PHY 99-12312.

NEUTRALIZER ANALYSIS AND MASS SELECTION OF FR. Daniel Feldman, University of Maryland at Baltimore County, Gene D. Sprouse, Luis A. Orozco, Matthew R. Pearson,

Raymond P. Fliller, State University of New York at Stony Brook.

The process of compressing and cooling radioactive ions in both physical and six dimensional phase space allows for the testing of atomic theories associated with various alkali metals. Research conducted at Stony Brook's Nuclear Structure Laboratory has resulted in the successful trapping of both rubidium and francium atoms for analysis via laser spectroscopy. The main objective for the trapping is to study atomic parity non-conservation and to conduct time reversal experiments with the radioactive atoms. The Stony Brook group creates an oxygen beam of 100 MeV energy, using a superconducting LINAC to bombard a heated gold target. This nuclear reaction produces francium subject to the reaction: $^{18}O + ^{197}Au \rightarrow Fr + xn$. Fr, and other alkali ions, are released from the gold through diffusion processes and are then sent down a beam line at energies of 10keV. Electrostatic lenses guide the ions until they reach a thin foil that neutralizes the Fr^+. The francium is injected into a Magneto-Optical Trap (MOT) coated with dry film for trapping and cooling. Currently new traps are being assembled for which the neutralizer is located inside the MOT. My contributions to this project involved analyzing the thermodynamic properties of neutralizers of various elements with the use of a vacuum system and an optical pyrometer as well as devising a Wien filter to mass select francium ions. Francium released from the neutralizer is temperature dependant, as is the dry film coating in the MOT. Thus, the measurement of varying foil temperatures for future comparison with experimental data was conducted. Emissivities of the foils were calculated from this data and their agreement with known values suggests that the data is accurate. The Wien filter, a set of Helmholtz coils coupled with two steering plates, subjects the ion beam of energy 10keV to perpendicular forces due to constant electrical and magnetic fields. The necessary parameters for the deflection of the undesired ions were determined, and are to be compared with experimental data. This study was supported by NSF Grant No. PHY 99-12312.

SYSTEMATIC AND RANDOM ERRORS IN THE PHOTOMETRIC REDSHIFT TECHNIQUE. Brian Levine, Kenneth Lanzetta, Alberto Fernandez-Soto, Sam Pascarelle, and Noriaki Yahata, State University of New York at Stony Brook**.**

The photometric redshift technique allows for accurate determination (within (delta z)/(1+z) < 7%) (where delta z is the difference between the spectroscopic and photometric redshift values) of redshifts of faint high-redshift galaxies, where spectroscopic techniques fail. Intervening neutral hydrogen clouds between us and a high-redshift galaxy can absorb much of the rest frame ultraviolet light emitted by the galaxy, imprinting a characteristic broad-band signature. Spectroscopic techniques rely on narrow emission or absorption lines; for faint galaxies (with spectra recorded with low signal-to-noise ratios) these lines are hard to identify. In contrast, photometric redshift techinques rely on broad-band spectral features of galaxies. The photometric technique provides a likelihood function for the redshift of the galaxy. There are random and systematic errors that must be taken into account. Random photometric errors arise in the measurements and are assumed to be non-systematic. Systematic errors arise when comparing broad-band spectra of galaxies to 6 galaxy templates created by Lanzetta et al. These templates are not perfect, and were pieced together from observational data. To compare photometric results with spectroscopic results, and to test the templates, we assumed that systematic errors would take a gaussian form. Using 146 galaxies in the Hubble Deep Field, we got likelihood functions for each, then convloved each with a gaussian that varies with (delta z)/(1+z), and minimized the sigma by comparing the new probability curve with the known spectroscopic redshifts (previously measured by other groups). We found a best-fit sigma of 0.06, indicating that the technique and the templates are very accurate. We also found that sigma, when varied as delta z, is different in three intervals. Below z = 2, the Lyman alpha forest (Lyman alpha lines at many redshifts, and hence wavelengths, arising from intervening neutral hydrogen) is below the range of the filters, and sigma = 0.09. From z = 2 to 4, stochastic variations in the Lyman alpha forest lead to a sigma of 0.29 and from z = 4 to z = 6, sigma drops to 0.18, as most of the light from the galaxy has been absorbed. We modeled galactic spectra at many redshifts to see how these stochastic variations in the Lyman alpha forest affect the photometry, and to understand the systematic errors. Some of the systematic error arises from not having perfect templates, but none better exist yet. The models used neutral hydrogen clouds that were not clustered, but that were distributed through redshifts, column densities, and linewidths, known from previous work. Clustering the clouds may produce the correct affect on the Lyman alpha forest. This study was supported by NSF Grant No. PHY 99-12312.

DIFFUSE INTERSTELLAR BANDS. Diana Pitt and Deane Peterson, State University of New York at Stony Brook.

Diffuse interstellar bands (DIBs) are spectral features characterized by breadth. These features are believed to be interstellar because their positions are independent of stellar motion. DIBs appear in the spectra of stars because their carriers, thought to be solid particles or fragments of complex carbon molecules, are found in intervening interstellar clouds. I have analyzed the spectra of 173 stars known as A-F supergiants searching for two DIBs previously discovered in the infrared region. The stars are predominantly located in the Galactic plane and were observed in the Northern Hemisphere. I have documented the variation of strength of these two bands in different stars. I have also correlated the DIB intensity with the stars' amount of extinction due to dust in the intervening cloud(s). Coupled with the stars' estimated distances, my data will help map out the distribution of DIB carriers in the plane of the Milky Way. This study was supported by NSF Grant No. PHY 99-12312.

QUANTUM BINDING WITH NO CLASSICAL FORCE. Ryan Requist, University of North Dakota, Alfred Goldhaber, and C. N. Yang, Institute for Theoretical Physics, State University of New York at Stony Brook.

Previous research has focused on the two-dimensional characteristics of the Aharonov-Bohm effect. An idealized three-dimensional problem consists of a charged particle interacting with an infinitely thin ring of magnetic flux. If the ring contains a superconducting quantum of flux, then a bound state exists for the charged particle, even though it never contacts the ring and is never in a region where the Lorentz force is non-zero. When the particle crosses the boundary of a sphere contiguous to the ring, the resulting AB induced phase shift restricts the wave function to even interior and odd exterior partial waves. Conservation of angular momentum requires that the particle change the angular momentum of the ring to escape. We calculate the wave function for a state in which the particle does not possess the energy necessary to impart spin to the ring and is therefore bound. This study was supported by NSF Grant No. PHY 99-12312.

SPECTROSCOPIC STUDY OF LAMNO$_3$ WITH MARTIN-PUPPLETT VERSION OF THE MICHELSON SPECTRAL INTERFEROMETER. Justin Schneiderman, Worcester Polytechnic Institute, Laszlo Mihaly and Diyar Talbayev, State University of New York at Stony Brook.

The absorption spectrum of LaMnO$_3$ is being studied using the Martin-Pupplett version of the Michelson spectral interferometer and computer generated Fourier Transform software for spectroscopy. The spectroscopic method is important to study before measurements are taken to ensure quality data acquisition. Two white light far-infrared sources are used in this apparatus, one is a customary 4 ampere quartz mercury arc lamp located within the spectrometer, and the other, Beamline U12IR at the National Synchrotron Light Source at Brookhaven National Labs. The performance of the light sources was studied with the interferometer before any measurements of the sample were taken. The U12IR beamline demonstrated a marked improvement in the speed of the measurement because of its high intensity and brightness (the beamline having approximately 50x the intensity of the lamp). The spectroscopic method and apparatus used here is important because it is the first to have the capability to create a high resolution absorption spectrum at very low infrared wave numbers (below 30 wave numbers) on small (less than 4 mm radius) and low transparency samples. It is at these low wave numbers that the spin resonance of LaMnO$_3$ is found and is being measured for the first time with a spectral interferometer. The LaMnO$_3$ sample used is 4 mm in radius and opaque to visible light, making the sensitivity of the interferometer and intensity of Beamline U12IR critical to the measurements taken. These measurements taken of the LaMnO$_3$ sample show that the absorption peak goes to approximately 8 wave numbers as the critical temperature (about 140K) is approached. It is at this wave number that the magnetic moments of the LaMnO$_3$ are predicted to precess within their crystalline structure. The anisotropy field inherent in the crystal creates this precession, which is subsequently driven by the incoming radiation. This study was supported by NSF Grant No. PHY 99-12312.