EFFICACY OF A NATIVE BEE FOR POLLINATION OF EASTERN ORCHARDS. Melanie Cutter & Mark Kraemer, Agricultural Research Station, Virginia State Univ., Petersburg, VA 23806. The blue orchard bee, *Osmia lignaria* Say, has been shown to be an excellent pollinator of tree fruits in western North America. A subspecies of this bee is widespread in eastern North America and may be similarly effective. The objective of our study was to determine pollen preference of this bee with respect to nest placement. Sets of 4 nest shelters were placed within the orchard, an adjacent hardwood forest, and along the border between orchard and forest. Each shelter contained a wood block with 24 nest holes. Prior to apple bloom, each nest shelter was provided with 3 nests of adult bees that were ready to emerge. Weekly images of nests were taken to date the completion of new nests. Pollen samples were collected from individual nest cells in early May, after the end of apple bloom. Random samples of 300 pollen grains per bee nest cell were identified to species using a scanning electron microscope. The results indicated that the bees preferred to collect pollen from nearby Eastern redbud (*Cercis canadensis* L.) trees than the orchard fruit trees. Placement of nest shelters did not make a significant difference in pollen preference. We concluded that eastern redbud trees near orchards could reduce the pollination efficacy of *O. lignaria* within eastern orchards.

Astronomy, Mathematics and Physics with Materials Science

OPTICAL CHARACTERIZATION OF SELF-ASSEMBLED POLYMER/MICROPARTICLES THIN FILMS. Daniela M. Topasna & Gregory A. Topasna, Department of Physics and Astronomy, Virginia Military Institute, Lexington, VA 24450. Thin films are an important component in many optical and electrical devices, including optical filters. We fabricated multiple layer thin films of sodium salt of poly(styrene sulfonate)/titania using a layer-by-layer self-assembly method. The optical properties of these films were determined based on the calculations of a theoretical numerical model that we developed. The UV-VIS-NIR measurements of these films performed in the 300-2400 nm range confirmed the relationship between the type and number of layers and were consistent with the modeled transmittance values at specific wavelengths.

DETERMINATION OF PHOTON ARRIVAL RATES AND S/N RELATIONSHIPS FOR THE VIRGINIA MILITARY INSTITUTE'S 0.5 METER TELESCOPE. Gregory A. Topasna & Daniela M. Topasna, Virginia Military Institute, Lexington, VA 24450. We determined the photon arrivial rate for unfiltered CCD images using the Virginia Military Insitute's 0.5 meter telescope. Observations of the open clusters NGC 1502 and M 44 were made using an Alta U6 CCD camera with different integration times. Aperture photometry was performed on stars of known visual magnitude and, using the standard CCD equation, the signal-to-noise ratio was determined for the different integration times. The photon arrival rate for each star was then determined from these data and the CCD equation. As a function of magnitude m the photon arrival rate is approximatly equal to $10^{(9.26-m/2.4)}$. The

airmasses of the cluster images differed by ~1 and our analysis showed that arrival rates were not strongly dependent on this airmass difference.

LOVE WAVE PROPAGATION IN A POROUS ELASTIC LAYER UNDER RIGID BOUNDARY. Shishir Gupta & Dinesh K. Majhi, Dept. of Applied Mathematics, Indian School of Mines, Dhanbad-826 004, India. In this paper, propagation of Love waves in a porous elastic layer under a rigid boundary over a porous elastic half space has been considered. Pores contain nothing of mechanical or energetic significance. The study shows that such a medium transmits two types of Love waves. The first front depends upon the change in volume fraction of the pores. The second front depends upon the modulus of rigidity of the elastic matrix of the medium and is the same as the Love wave in an elastic layer under a rigid boundary over an elastic half-space. It is found that the phase velocity of Love waves is considerably influenced by porosity. It is also observed that the first wave front is faster than that of shear wave in the porous medium due to change in volume fraction of the pores.

THERMALLY DRIVEN ATMOSPHERIC ESCAPE: MONTE CARLO SIMULATIONS FOR TITAN'S MULTI-COMPONENT ATMOSPHERE. Orenthal J. Tucker & Robert E. Johnson, University of Virginia, Charlottesville, VA., 22904. Kinetic Monte Carlo model simulations of thermal escape from Titan's upper atmosphere are used to reproduce the Cassini INMS density measurements of N_2 and CH_4 without requiring significant loss rates as proposed by recent continuum models. In the kinetic model intermolecular collisions between N_2, CH_4 and H_2 are described using temperature dependent cross sections and allowing the exchange of internal energy as well as translational between molecules. Fits to INMS density data for N_2 obtained when Titan was in Saturn's plasma sheet indicate H_2 has a Jeans parameter ~3 at the exobase. The kinetic Monte Carlo simulations obtain an H_2 loss rate ~1 $x10^{28}$ H_2/s which is essentially the Jeans rate. The results from multi-component kinetic simulations are used to examine the change in the H_2 escape rate when Titan is not in the plasma sheet to when it is in the plasma sheet using average magnetospheric conditions to obtain the energy deposition by the flux to O+ and H+ into Titan's upper atmosphere.

THE MEANING OF EINSTEIN'S EQUATION. Emory F. Bunn, Physics Department, University of Richmond, Richmond, VA 23173. The Einstein field equation, relating spacetime curvature to the matter stress-energy tensor, is one of the fundamental laws of physics, but, due to the level of mathematical machinery required to express it, it is generally omitted from the undergraduate curriculum. However, it is possible to express the entire content of this equation in relatively simple geometric terms, without the apparatus of tensor calculus. To be specific, the Einstein equation relates the rate of change of the volume of a small ball of initially-comoving test particles to the density and pressure of matter in the ball's interior.

THE COSMIC MICROWAVE BACKGROUND RADIATION. Emory F. Bunn, Physics Department, University of Richmond, Richmond, VA 23173. Observations of the cosmic microwave background radiation are among the chief causes of the rapid advance in our understanding of cosmology over the past 20 years. Microwave background temperature anisotropy measurements have confirmed the presence of acoustic waves in the early Universe, providing support for the standard gravitational instability paradigm and allowing us to deduce the properties of acoustic waves in the early Universe and hence to measure cosmological parameters. Attention is now shifting to measurements of microwave background polarization. Polarization measurements can shed light on several aspects of cosmology, but arguably the most exciting is the prospect of detecting "B modes," which could provide direct evidence of an inflationary epoch. Although existing data are in most ways remarkably consistent with the standard cosmological model, some apparent anomalies have been noted on large scales. The significance of these anomalies is hotly debated. To settle the question, we need a new data set that probes perturbations on similar scales but is statistically independent of the existing measurements. Future microwave background polarization maps may provide such a data set.

ORBITS AND SCALING FOR AN ISOTROPIC METRIC. J. D. Rudmin, Dept. of Integrated Sci. and Tech., James Madison University, Harrisonburg VA 22807. Scaling of physical quantities shows the symmetries of an isotropic metric, including extension to the equivalence principle. For example, invariance of Planck's constant under gravitational scaling provides consistency of general relativity with quantum mechanics. Invariance of charge provides consistency with electromagnetism. Transitivity of scaling eliminates the traditional need for a globally preferred reference frame. Rather, diagonalization of the metric yields local rest frames. Scattering, orbital period, and precession offer ways to distinguish an isotropic from a Schwarzschild metric.

AN ANNUAL PATTERN IN WATER TEMPERATURE DIFFERENTIALS BETWEEN ADJACENT REGIONS OF THE CHESAPEAKE BAY, VIRGINIA. T.C. Mosca III, Dept. of Mathematics, Rappahannock Community. College. and W. C. Coles, Div. of Fish and Wildlife – Dept. of Planning and Nat. Res. Each winter the Atlantic Ocean, lower Chesapeake Bay, and the major tributaries cool to about the same temperature. In the spring, water farther from the ocean warms faster, and the difference in temperature between the bodies grows. The maximum difference occurs in spring near the ocean, in summer farther upstream. Warming occurs by the influence of solar radiation at the surface, the rate of which is the same in all locations. The ocean simply has more water per unit of surface area, and warms more slowly. The lower regions of Chesapeake Bay and the rivers will warm more slowly than the upper regions because ocean water circulates in these parcels. The lag in warming is attributable to the exchange of energy with the Atlantic Ocean, even at the farthest distances examined in this study. The different timing of the lags in the maximum temperature differences that occur in the upper reaches (June vs. April) is an artifact of distance from the ocean. The only area where this pattern changes is in the lower portion of the Rappahannock River, probably due to a ledge across the mouth of the river, where depths quickly become

half that of the nearby deep zone. We examined the lags as differences in long-term average monthly temperatures of regions of the Bay and tributaries. This feature of energy transfer is probably present in other estuaries, because a defining feature of an estuary is density driven circulation.

EFFECTS OF THE CORIOLIS FORCE ON THE LARGE-SCALE ATMOSPHERIC TURBULENCE. Iordanka N. Panayotova, Department of Mathematics and Statistics, 4700 Elkhorn Ave., Old Dominion University, Norfolk, VA 23529. Earth's rotation causes an inertial force, known as the Coriolis force. The Coriolis force is small but its effects become noticeable for motions occurring over large distances and long periods of time (large-scales motions). Well known examples of large-scale formations in the atmosphere are cyclonic/anticyclonic systems, or jet-streams and atmospheric waves. On the other hand the large-scale geostrophic turbulence is a chaotic three-dimensional nonlinear motion of the fluids that are near to the state of geostrophic and hydrostatic balance. A simple three-dimensional model of the tropopause dynamics is a model with introduced a quasi-horizontal interface separating regions of homogeneous potential vorticity of different values. The quasi-geostrophic (QG) approximation to this model reduces dynamics of the flow to quasi-two-dimensional turbulence. In this way, the three-dimensional flow is entirely modeled by the horizontal advection of potential temperature on the interface (surface quasi-geostrophic (sQG) model). Including weakly non-linear dynamics and the meridional variation in the Coriolis parameter (β-effect) will result in the so called β-sQG+1 numerical model. Here this model is applied to study the effects of the Earth's rotation on the large-scale atmospheric turbulence. The numerical simulations capture some important dynamical characteristics of the large-scale atmospheric dynamics known from observations, in particular the meridional asymmetries in eddies spatial and time scales, and their orientation.

UNCERTAIN GROUND: MAPPING ERRORS THROUGH THE POM-SAT MODEL OF PALEOCLIMATE RECONSTRUCTION. Marshall G. Bartlett, Dept. of Physics, Hollins University, Roanoke, VA 24020. Borehole temperature-depth profiles contain information about ground surface temperatures (GST) a region has experienced in the past and provide complementary information to the surface air temperature (SAT) record of climate change. The borehole method of climate reconstruction assumes the dominant heat transport mechanism in the upper few hundred meters of the earth's crust is conduction; mathematically, conduction is a compressive (information losing) mapping. Consequently, the solution obtained in non-unique. One robust means of dealing with the non-uniqueness problem is to limit the number of parameters sought in the solution space. However, even when only a single parameter (the pre-observation mean GST, or POM) is sought in the inversion, a certain amount of a priori information must be assumed. I am interested in how uncertainties in this a priori information are mapped into uncertainties in the solution space. I perform a Monte Carlo analysis to investigate how uncertainties in our model of the ground thermal regime, SAT observations, and the background geothermal gradient are mapped into the solution space of the POM-SAT method of

climate reconstruction from borehole data. Results indicate that uncertainties in the SAT time series and thermal parameterization of the ground are reduced by an order of magnitude, while uncertainties in the geotherm are magnified by an order of magnitude in the solution-space.

Biology
with Microbiology and Molecular Biology

THE EFFECTS OF BACTERIOPHAGE INFECTION ON *BACILLUS ANTHRACIS* DETA STERNE AND *BACILLUS THURINGIENSIS*. Catherine A. Johnson & Lynn O. Lewis, Department of Biological Sciences, University of Mary Washington, Fredericksburg, VA 22401. *Bacillus anthracis* and *Bacillus thuringiensis* are soil dwelling bacteria that are capable of forming endospores. These bacteria go through the processes of sporulation and germination to form the endospores and vegetative cells. Both species of bacillus can be found in various soil samples, along with species of bacteriophages that target each bacterium. The goal of this research was to isolate one temperate bacteriophage for *Bacillus anthracis* Delta Sterne (Delta Sterne) and one temperate bacteriophage for *Bacillus thuringiensis* Al Hakam (Al Hakam) and then determine the effects the bacteriophages have on the sporulation and germination processes for Delta Sterne. A temperate bacteriophage was isolated for each bacillus species, with the one that infects Delta Sterne being called Texas 1 4CI. It was able to cross infect Al Hakam, but the Al Hakam temperate phage was unable to cross infect Delta Sterne. There were no apparent morphological differences between colonies of infected Delta Sterne and uninfected Delta Sterne through sporulation and germination. However, it appears that with successive sporulation and germination, the infectivity of the bacteriophage for Delta Sterne increases from 1 plaque at 10^{-3} dilution, to 32 plaques at 10^{-3} after a second sporulation and germination. (Supported by UMW Undergraduate Student Research Grant.)

CHARACTERIZATION OF MYCOBACTERIOPHAGE VENKMAN. Thien T. Phan & Lynn O. Lewis, Department of Biological Sciences, University of Mary Washington, Fredericksburg, VA 22401. Bacteriophage are abundant in the environment and have co-evolved with the bacteria they target. Through soil collected, we were able to have a better understanding of how mycobacteriophage interact with their host, *Mycobacterium smegmatis*. One bacteriophage (Venkman) was chosen for genomic sequencing. Restriction enzyme digests were performed to compare the phage's DNA to other known bacteriophage DNA. Electron microscopy was performed to examine the morphology of the Mycobacteriohpage. By using different bioinformatics programs, we determined that the Mycobacteriophage Venkman is in the F cluster and within the F1 subcluster. The genome size is approximately 50 kbp – to 60 kbp, but is unfinished at this time. Further investigations are still being performed on the genome of Mycobacteriophage Venkman. (Supported by UMW Undergraduate Student Research Grant.)