

"Einstein's Contributions to Optics and Photonics"

Spring Meeting of the Illinois Section of the AAPT

April 8-9, 2005

Department of Physics, Southern Illinois University Edwardsville, Edwardsville, IL

Friday, April 8, 2005

7:30 - 9:30 **Registration - Lobby of the Science Lab Building.** All other times - Go to the physics department office room SL 2331. Please make out your checks to "ISAAPT".
and
11:30 - 1:30

9:00 - 12:00 **Workshop W1. "Waves and Color - Mostly on the Cheap"**, Ann Brandon and Debbie Lojkutz, Joliet West High School, Science Lab Building 1218.

8:00 - 12:00 **Workshop W2. "Photoelectric Effect"**, Mark Schoeber, John Burroughs High School, Peck Building 1410.

9:00 - 12:00 **Workshop W3. "Inquiry Based, In-class Astronomy Activities with Hands-on Equipment"**, Rebecca Lindell and Tom Foster, SIUE, Science Lab Building 0225.

12:00 - 1:00 **Lunch - on your own**

4:00 - 6:00 **Registration - Lobby of the Science Lab Building.** Please make out your checks to "ISAAPT".

1:00 - 1:15 **Welcome - Dean Kent Neely**, College of Arts and Sciences, Science Lab Building 0210

** Indicates participation in the Student Research Symposium. Namely, papers A1-A5.*

1:15 - 2:30 **Session A - Contributed Papers - SL 0210**

Session Chair: Tom Foster, SIUE

1:15 - 1:30 - A1

*** Correlation of Torque Sensitivity and Magnetic Hysteresis to Sensor Diameter in ESR420.**

Jacob R. Hoberg, Daniel K. Pratt, Jason T. Orris, and Mark S. Boley, Western Illinois University, Macomb, IL 61455. In my earlier research, I have found that the 14% chromium stainless tool steel, ESR-420, is an excellent candidate for torque sensing applications at the large scale of 18 mm diameter in the form of a hollow sensory shaft. My more recent work has focused on producing solid and hollow sensory shafts of diameters 14 mm, 10 mm, and 5mm size, respectively. In each case, torque load sensitivities and magnetic hysteresis properties have been measured both before and after the standard heat treatment on the samples. The results I have obtained will be correlated to the sensor diameter to determine whether smaller-scale applications of this technology are indeed feasible.

1:30 - 1:45 - A2

*** Effects of Quenching Medium and Cooling Rate on Torque Sensitivity in D-2.** *Daniel K. Pratt, J. Matthew Kerr, Jason T. Orris, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455.

Previously, I have found that the 12% chromium highly wear-resistant tool steel, D-2, is an excellent candidate for long-term torque sensing applications such as those in the automotive industry. Its torque sensitivity and magnetic hysteresis properties were found to slightly improve subsequent to a water quench and a standard annealing and cooling rate. My more recent work has focused on producing identical sensory shafts and subjecting them to slower cooling rates in their annealing process, as well as investigating the effects of an oil quench rather than a water quench. In each case, torque sensitivities and magnetic hysteresis properties have been measured both before and after the quench

and annealing of the samples. The results I have obtained suggest that the quenching medium and cooling rate are crucial to the enhancement of the sensory function.

1:45 - 2:00 - A3

* **Use of the Magnetic Force Microscope (MFM) to investigate Domain Wall Parameters in High Chromium Content Steels.** *Matthew W. Beckner, Jacob R. Hoberg, Gregory M. Sollenberger, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455. In this talk, I will discuss the magnetic force microscopy (MFM) results I have obtained for the study of the center domain walls established in four different steel torque transducers of chromium contents ranging from 5 - 14%, known as H-13, A-2, D-2, and ESR420. Magnetic domain wall widths and heights have been directly measured by fitting sequential MFM scans and will be correlated to the torque load sensitivities and axial magnetic hysteresis properties of these sensory shafts. Conclusions will then be drawn concerning the optimal domain wall parameters that are essential to the torque sensor function and how these are correlated to the chromium content.

2:00 - 2:15 - A4

* **Deconstructing Huygen's Principle.** *Erick Blomberg*, Bradley University, Peoria, IL 61625. Although Huygen's Principle is covered in nearly every undergraduate physics text and curriculum, many instructors are unaware that Huygen's Principle is invalid without making certain ad hoc assumptions with no physical justification. This paper illuminates these ad hoc assumptions and discusses the contemporary treatment of Huygen's Principle in contemporary undergraduate physics curricula. Finally we question the validity of Huygen's Principle as a true scientific principle.

2:15 - 2:30 - A5

* **Novel Restructuring of Annealed Ag Films on Si (111).** *Steven Binz, D. C. Ludois, and K. R. Kimberlin*, Bradley University, Peoria, IL 61625. Silver films of 1.3 ML (0.85 ML above the wetting layer) have been grown epitaxially at 104 K using in situ molecular beam epitaxy. The surface was then annealed to successively higher temperatures starting with room temperature and ending with 600 K. Allowing the sample to cool to room temperature between each anneal to study the surface which was done using reflective high energy electron diffraction (RHEED) and scanning tunneling microscopy (STM). The data show that as the temperature of the anneal is increased from 400 K to 600 K, the islands created become taller and wider but maintain their varied and unusual heights (up to 20 atomic layers), vertical sides, and flat tops. These results will be discussed in an *electronic growth* model where Quantum Size Effects are thought to stabilize particular island heights, producing this unusual flat island growth.

2:30 - 3:00 - Break - SL 0225

3:00 - 4:00	<p style="text-align: center;">"Photonics at SIUE"</p> <p style="text-align: center;">Abdullatif Hamad - Southern Illinois University Edwardsville SL 0210</p> <p>This talk will focus on the photonics program and research opportunities in the Department of Physics at SIUE. The physics graduate program at SIUE provides diverse research opportunities in optics/photonics. Currently, the group works in the areas of thin film optics, optical spectroscopy, nonlinear optics, holographic data storage, ultrafast optical spectroscopy, and photon counting in scintillating optical fibers. Members of the photonics group will talk about their research interests.</p>
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4:00 - 4:45 Session B (concurrent with Session C) - Contributed Papers - SL 0210

Session Chair: Fred Zurheide, SIUE

4:00 - 4:15 - B1

Reinforcing Energy Conservation. Lenore Horner, Southern Illinois University Edwardsville, Edwardsville, IL 62026. I present a compact graphical method of tracking energy both through changes in form within a system and through transport into and out of the system. The method makes energy conservation very clear and encourages the user to think explicitly about transitions as well as particular points in the process. The method also lends it self to linkage with quantitative problem-solving.

4:15 - 4:30 - B2

What Would You Call That? Dave Sykes, Lincoln Land Community College, Springfield, IL 62794-9256. Recently a workshop was conducted for the Regional Education Center in Carlinville, Illinois to assess how high school physics teachers use key words in their teaching. The assessment tool was a survey that allowed the participants to choose one or more of 10 commonly used words in Physics to characterize a concept in Physics. The results and conclusions of the survey will be presented along with an opportunity for the attendees to take the survey.

4:30 - 4:40 - Take Fives

1. *David Cornell*, "Invitation to visit the Principia Telescope"
2. *Daniel Ludois*, "The Wimshurst Machine"

4:40 - 5:00 - Break - SL 0225

** Indicates participation in the Student Research Symposium. Namely, papers C1-C4.*

4:00 - 5:00 Session C (concurrent with Session B) - Contributed Papers - SL 0226

Session Chair: Rebecca Lindell, SIUE

4:00 - 4:15 - C1

*** Europium Doped Silicate Glass Laser.** Amy Winkler and Abdullatif Hamad, SIUE, Edwardsville, IL 62026. In previous research performed at SIUE, it has been observed that europium doped silicate glass exhibits some desirable characteristics of a laser medium. The most notable of these characteristics is that europium doped silicate glass fluoresces significantly when excited at by radiation of 532nm. The goal of our research project is to attempt to make a laser using this europium sample and to quantize its characteristics. So far, all attempts have been unsuccessful in making a laser due to the thermal characteristics of the glass host material, which cause the laser cavity to be unstable, and insufficient gain of the laser medium. Most recently, we have observed what appears to be superfluorescence of the europium sample at the output of the laser cavity. If the output is indeed superfluorescence, then we believe that we may be very close to making the europium sample lase.

4:15 - 4:30 - C2

*** Presenting the Free Online Concept Inventory Analyzer (FOCIA).** Joseph Beuckman, Scott Franklin, and Rebecca Lindell, Southern Illinois University Edwardsville, Edwardsville, IL 62026. Computing technology now makes possible previously impractical methods of analyzing student assessment data beyond the traditional "total average score" approach. Our new, web-based tool will allow researchers in any location to upload their data and quickly download a complete analysis report. Analyses included with this tool are traditional test statistics, model analysis theory results, traditional item analysis, concentration item analysis, pre and post test comparison, including the calculations of gains, normalized change and effect size. The tool analyzes data from several popular instruments from the Physics and Astronomy education research community, including the Force Concept Inventory (FCI)

and the Lunar Phases Concept Inventory (LPCI). In this talk, we will discuss how to access and use our analysis tool. Instructors and researchers are encouraged to use the latest version of this tool via our Web site.

4:30 - 4:45 - C3

* **Design and Construction of a Trebuchet.** *Christopher Petta, Jauhar Khalid, Ben Morhardt, Chris Williams, Nate Schumaker*, Highland Community College, Freeport, IL 61032. Throughout time mechanical energy was harnessed to create some very destructive weapons. One of those such weapons was the trebuchet. Although the physics behind the machine hasn't changed for hundreds of years its destroying capability evolved from killing small animals to being able to break through castle walls.

4:45 - 5:00 - C4

* **Flinging the Engineering Program into the Future.** *Jauhar Khalid, Chris Petta, Ben Morhardt, and Nate Schumaker*, Highland Community College, Freeport, IL 61032. With enrolment in Physics and Engineering down across the country, the SPS chapter at Highland Community College decided to make a conscious effort to attract potential students towards Physics and Engineering. We designed and constructed a sixty-nine foot trebuchet to demonstrate how the laws of Physics can be applied in real-life situations. The event lured over 300 area high school students who thoroughly enjoyed themselves as we launched bowling balls, cement basketballs, and an 80-pound frozen pumpkin. We believe that this event was a huge success in generating interest in Science at HCC and should serve as an example for all colleges and physics communities alike.

5:00 - 6:00 Lab Tours

6:00 - 6:30 Social time - cash bar open in the Mississippi and Illinois Rooms of the **Morris University Center**

6:30 - 8:00 Banquet - Morris University Center

Presentation of the *Outstanding High School Physics Teacher Award* to Michael Kennedy.

<p>8:00 - 9:00</p>	<p style="text-align: center;"><i>"Teaching the Current Generation of Students in the World Year of Physics"</i></p> <p style="text-align: center;">Kathy A. Harper - Physics Education Research Group, The Ohio State University Morris University Center - Mississippi and Illinois Rooms</p> <p>Physics has seen substantial changes since Einstein published his seminal works. Likewise, the times in which our students have grown up are different than Einstein's time and (although we may not want to admit it) ours. The generation of students now populating our high schools and colleges are referred to as the Millennials. Research has shown them to be different from the "Gen Xers" who preceded them in many ways. This talk will summarize some of the research findings on the Millennials and share possible strategies for teaching them effectively.</p>
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Saturday, April 9, 2005

7:00 - 8:00 ISAAPT Council meeting - Presiding: Kimberly Shaw, President, ISAAPT. SL 1218
7:30 - 9:30 Registration - Lobby of the Science Lab Building. Please make out your checks to "ISAAPT".

* Indicates participation in the Student Research Symposium. Namely, papers D1-D8.

8:00 - 10:00 Session D (concurrent with Session E) - Contributed Papers - SL 0210

Session Chair: David Kaplan, SIUE

8:00 - 8:15 - D1

* **Numerical Simulation of Thermal Conductivity in Nano-Scale Silicon Thin Films.** *Xavier Lange, Jie Zou*, Eastern Illinois University, Charleston, IL 61920. We study how thermal conductivity changes in silicon thin films when the thickness shrinks to nanometer scale. The importance of this research lies in the fact that continuous downscaling of contemporary electronic components leads to an increase in the heat dissipation density and in turn an associated problem of device reliability. An understanding of thermal conductivity in semiconductor nanostructures becomes particularly important. Numerical simulations are performed to find the phonon dispersion relations for the shear modes in silicon thin films ranging from 10 nm to 110 nm. Phonon dispersion relations are modified compared to those in the bulk materials. The cause for the modification is analyzed. Future work includes the simulation of thermal conductivity in silicon thin films using the corresponding phonon dispersion relations. This research project has been submitted for the Undergraduate Research Grant sponsored by the Honors College at Eastern Illinois University.

8:15 - 8:30 - D2

* **The Formation of Domain Walls with Striped Symmetry in Submonolayer Pentane and Hexane on Graphite.** *Cary L. Pint and M.W. Roth*, University of Northern Iowa, Cedar Falls, IA 50614. This study employs molecular dynamics simulations to analyze the phase behavior in pentane and hexane physisorbed onto the graphite basal plane at submonolayer coverage. In particular, this work concentrates on the formation of striped symmetry domain walls, which have been recently investigated for hexane through intensive diffraction experiments with the results indicating that the observed domain-wall behavior is a new feature to physisorbed films. By using a method of uniformly expanding the computational cell in the direction of least commensurability, this work reports domain wall formation in both hexane and pentane that involves fully commensurate regions of molecules in a solid phase separated by low-density regions of disorder, similar to that reported in experiment. Furthermore, this study concludes through several variations that the mixed intermolecular interactions as well as periodic boundary conditions both contribute significantly to the simulated formation of domain walls in these two submonolayer films.

8:30 - 8:45 - D3

* **Pair Creation Process in Supercritical Fields.** *Kevin Cooley, P. Krekora, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. We investigate the pair-production process in vacuum induced by a supercritical field using space- time resolved solutions to relativistic quantum field theory. In the transition from the early time regime that is determined by the temporal turn-on of the field to the steady state regime characterized by a linear growth of the pair production probability in time, we compare numerical data obtained from the temporally and spatially resolved quantum field theory with analytical estimates. We test the range of validity of the Schwinger formula for supercritical fields with a finite spatial extension and strength. In the long-time regime, we analyze the electron-positron creation process from vacuum in which multiple pairs are produced. We find that for a supercritical potential of finite extension, the time-dependence of the production rate of pairs is described by four distinct regimes that have their direct counterparts in the time evolved spatial density of the particles. * Supported by grants of the NSF, Research Corporation, ISU Honors Program.

8:45 - 9:00 - D4

* **Ensemble vs. Frequency Averages for a Random Scattering Medium.** *Matthew Narter, S. Menon, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. For system of randomly arranged plane-parallel dielectric layers with randomly varying index of refraction and width, we compare the reflection coefficient derived from the Maxwell equations with that of the Boltzmann theory. For a strictly monochromatic field this coefficient is an oscillatory function of the laser frequency. We show how suitable frequency or ensemble averaging permits a comparison of the two theories. The calculation of the usual Boltzmann scattering coefficient from microscopic parameters can be improved to permit a better agreement with the exact Maxwell data. The frequency averaging in practice is much simpler to perform often times than the ensemble averaging. We would like to use this new result on the generator level to see if it is possible to get an improved theoretical equation of the Boltzmann equation. * Supported by grants of the NSF, Research Corporation, Illinois State URG and Honors Program.

9:00 - 9:15 - D5

* **Experimental Studies of Light Scattering in Milk.** *Sawyer Campbell, G.H. Rutherford, B.K. Clark, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. We have explored experimentally the propagation of a light pulse in a heterogeneous medium, such as milk. Using a (LabView) computer controlled translation stage we are able to collect scattered light from the input diode laser beam over 6 orders of magnitudes in intensity. We will also describe our first experiments to determine the scattering and absorption coefficients as well as the anisotropy of milk for various concentrations by measuring the scattered or absorbed light intensity as a function of the source-detector spacing. This apparatus will be used in the near future to study other proposed light scattering experiments and possible bio-optical imaging algorithms. * Supported by grants of the NSF, Research Corporation, ISU Honors Program.

9:15 - 9:30 - D6

* **Extended Diffusion Theory for Light Scattering in Milk.** *Trisha Blood, S. Menon, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. To extract optical properties of a turbid medium from experimentally collected light scattering data, we have explored theoretically the propagation of a light pulse in a heterogeneous medium, such as milk. From the theoretical point of view the process can be modeled by assuming that the laser photons perform a random walk type motion. We have developed a Monte-Carlo algorithm to simulate a laser pulse in a time-dependent turbid medium such as milk. The computer simulations are designed to get a better understanding of how spatial in-homogeneities that are embedded inside the milk modify the propagation dynamics and how they can be detected. I will also describe our attempt to extract optical properties such as the absorption and scattering coefficients as well as the anisotropy from the experimental data. * Supported by grants of the NSF, Research Corporation.

9:30 - 9:45 - D7

* **Reconstruct Embedded Images using Reflected and Transmitted Light.** *Kimberly McGill, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. We examine the range of validity of an optical imaging algorithm for a model diffusive medium based on intensity modulated laser light. The location and the scattering profile of an embedded object can be reconstructed from the reflected light as a function of the modulation frequency. We present a detailed derivation of the inversion algorithm and show how its limitations affect the quality of the image. * Supported by grants of the NSF, Research Corporation, ISU Honors Program.

9:45 - 10:00 - D8

* **Transmission of a Turbid Medium between Mirrors.** *Rebecca Wenning, Q. Su and R. Grobe*, Intense Laser Theory Unit, Illinois State University, Normal, IL 61790-4560. Using the one-dimensional Boltzmann equation we examine the optical scattering properties of a turbid medium that is located between two mirrors with controllable reflectivity. We focus on the question how these mirrors can be used to enhance the total transmission of an intensity modulated laser beam through this system. The analytical results show that for certain modulation frequencies the total transmission can be increased if the laser source is placed between the mirrors. This finding could improve diffusive imaging for those highly scattering media that are so extended that the laser light would not penetrate sufficiently deep in the absence of any mirrors. * Supported by grants from the NSF, Research Corporation and ISU Honors Program.

10:00 - 10:15 - Break - SL 0225

8:15 - 9:30 **Session E (concurrent with Session D) - Contributed Papers - SL 0226**

Session Chair: Tom Foster, SIUE

8:15 - 8:30 - E1

The Condition Of Illinois Physics Teacher Education Programs. *Carl Wenning, ISU; Kimberly Shaw, SIU-Edwardsville; Ken Mellendorf, ICC; Dave Sykes, LLCC.* At the fall 2004 meeting of the ISAAPT at Bradley University an ad-hoc committee was formed for the purpose of assessing physics teacher education programs in the state of Illinois. The task of the committee was to develop, disseminate, and tabulate a survey which was to be sent to the 23 institutions that have such a program. A summary of the committee's work and the results of the survey will be presented.

8:30 - 9:30 - E2

Discussion of the Issues presented in Paper E1

9:30 - 10:15 - Break - SL 0225

<p>10:15 - 11:15</p>	<p style="text-align: center;">"Exploring the Nanoworld"</p> <p style="text-align: center;">Eric Voss - Chemistry Department, Southern Illinois University Edwardsville SL 0210</p> <p>Atoms are the fundamental "building blocks" of everything in the world around us. In 1960, the physicist Richard Feynman asked the question, "What would happen if we could arrange atoms one by one the way we want them?" Today, the emerging fields of nanoscience and nanotechnology are enabling such control of the material world at the scale of atoms and molecules. "Nano" means a thousandth of a thousandth of a thousandth (one billionth).</p> <p>Materials with dimensions on the scale of nanometers can have fundamentally different properties and behavior from those of bulk materials. The nature of the nanoworld is such that its exploration depends on the combined viewpoints of chemistry, physics, engineering, and the biological sciences. Details of student-centered, nanotechnology-enriched resources will be shared with the group. They are available at the Web site (mrsec.wisc.edu/nano) of the University of Wisconsin-Madison Materials Research Science and Engineering Center (MRSEC). Each participant will also receive an "Exploring the Nanoworld: Try This!" packet of hands-on demonstrations.</p>
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11:15 - 12:00 Session F - Contributed Papers - SL 0210

Session Chair: Abdullatif Hamad, SIUE

11:15 - 11:30 - F1

Fourier Analysis, Reflection and Quantum Diffusion Approaches for Undergraduates. *David H. Kaplan*, Southern Illinois University Edwardsville, Edwardsville, IL 62026. An important issue in the education of students in both classical and quantum physics involves the development of intuition about Fourier analysis and the time dependence of superposition states. Students often arrive in upper division courses with only a very meager feeling for these concepts, as even the basic believability of Fourier expansions is all too often based on the simple quoting of theorems from mathematics courses. Particularly difficult for students is appreciation of the connection between normal mode analysis and the splitting of an initially stationary pulse into two moving halves followed by reflections at bound ends. Mathematical proofs of the equivalence, while not difficult, do not seem to provide much real insight to the average student. In the quantum case, since the Schrodinger equation is a diffusion equation, new diffusive coherence effects appear. In this talk, some approaches and examples selected to provide insight will be discussed.

11:30 - 11:45 - F2

Problem-Solving Isomorphs. *Tom Foster*, Southern Illinois University Edwardsville, Edwardsville, IL 62026-1654. The Southern Illinois University Edwardsville PACbER (Physics Astronomy Chemistry and Biology Education Research) Group has been using problem isomorphs within our non-major astronomy courses. Isomorphs are two problems which have identical solution paths, but different problem contexts. The first part of our astronomy isomorph pairing is an inverse square law problem in an everyday setting given on the first day of class. The second part has the students solving astronomical distance problems as part of the normal exams given during the class. We have determined that the isomorphs are measuring mathematics skills. We have also determined that students' basic mathematics skills are good, but they are less skillful in applying algebra. This presentation will provide evidence to support both claims.

11:45 - 11:55 - Take Fives

1. *Cliff Parker*, "Two Student Favorites and The Power of the Atmosphere"
2. *Lenore Horner*, "Changing the Speed of Sound"

12:00 - 1:00 Lunch - SL 0210. *It must be ordered with registration.* Pick up your lunch from SL 0225.
General meeting for the presentation of awards for the Student Research Symposium.

1:00 - Theory "Lab" Tour