

"What Research Has to Say About Introductory Physics Teaching"

Spring Meeting of the Illinois Section of the AAPT

April 7-8, 2006

Illinois Central College, East Peoria, Illinois

Friday, April 7, 2006

- 8:00 - 5:30 Registration - Main Building, Hall outside of Tranquility Room.** Please make out checks to "ISAAPT".
- 10:30 - 12:00 Workshop W1. "Guiding Instruction and Learning with an STS Approach",** Larry Kellerman and Jeff Constable, Illinois Central College, Main Building 212C.
- 10:30 - 12:00 Workshop W2. "Tasks Inspired by Physics Education Research (TIPERs)",** Curtis Hieggelke, Joliet Junior College, Tranquility Room.
- 10:30 - 12:00 Workshop W3. "Cracker Barrel Discussion: High School Physics Teacher Recruitment, Preparation, Induction and Retention",** David Sykes, Lincoln Land Community College and Carl Wenning, Illinois State University, Main Building 213B.
- 12:00 - 1:00 Lunch - Seating in Tranquility Room**

* Indicates participation in the Student Research Symposium. Namely, papers A1-A3

1:00 - 1:45 Session A - Tranquility Room

Session Chair: Ken Mellendorf

1:00 - 1:15 - A1

* **Using Raman Spectroscopy to Examine Carbon Nanotube Binding to Organic Molecule Monolayers.** *Chad M. Gilpin, Daniel K. Pratt, Saleem G. Rao, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455. In our study single-walled carbon nanotubes (SWCNT) were placed on a series of surfaces of bare SiO₂, and on bare Au over the SiO₂, and on thin films (monolayers) of polar organic molecules including 2MI, cysteamine, and MHA that were molecular stamped over the Au surfaces. We then made use of the technique of Raman spectroscopy to excite the vibrational modes of the SWCNT and thereby determine the nature of their surface attachment. Raman peaks investigated and compared for energy shifts resulted from the radial breathing mode (RBM-mode) vibrations, the longitudinal mode (G-mode) vibrations, as well as other more complex disorder mode (D-mode) vibrations. Comparison of the energy shifts (softening or hardening) of these modes, primarily the G-modes, leads us to believe that the SWCNT follow the patterning of the molecular stamping and that their ends are most strongly attracted to the polar organic molecules.

1:15 - 1:30 - A2

* **Effect of Tungsten Content on a Steel Magnetic Torque Transducer's Performance.** *Dennis T. Norton, Jason T. Orris, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455. We have studied comparatively the magnetoelastic properties of four high speed tool steels known as A-2, M-2, M-4, and T-15, respectively. The T-15 sample possesses a tungsten content of around 13%, the M-2 sample around 6%, the M-4 sample around 5%, and the A-2 sample none. Hollow steel shafts of around 2 cm outer diameter and 1.5 cm inner diameter, with lengths of around 7 cm, were fabricated from each sample, and subjected to axial and circumferential magnetic hysteresis measurements. The torque load sensitivity tests were performed both prior and subsequent to standard heat treatments for the steels consisting of oil quenching from high temperature and a slow annealing. The measured post-heat torque load sensitivity responses were around 200 uG/psi for T-15, 130 uG/psi for M-2, 108 uG/psi for M-4, and 60 uG/psi for A-2, which we believe is due to the variation in their tungsten content.

1:30 - 1:45 - A3

* **Torque Transducer Response as a Function of Ambient Temperature.** *Patrick R. Szczypinski, Jason T. Orris, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455. We have attempted to define the change in magnetoelastic response with ambient temperature for three commonly applied steel torque transducers, comprised of L-6, Kapstar (4% Nickel), and ESR-420 steel (14% Chromium), respectively, since applications of these transducers in real industrial or automotive settings are often in an immersed fluid environment where ambient temperature fluctuates between 0°C and 100°C on an irregular basis. Our studies over the easily attainable ambient temperature ranges in our

laboratory from 20°C to 56°C clearly show that in two of these samples there is little or no gain or loss to magnetoelastic response to applied torque, but rather that the magnetic background signal has a very definite positive slope. This leads us to conclude that by appropriately programming the transducer's sensory electronics to include this slope, we can ensure the applicability of the transducers over the required temperature range within given tolerances.

1:45 - 2:00 - Break - Tranquility Room

2:00 - 2:05	Welcome - Dean of Math/Science/Engineering - Tranquility Room
2:00 - 3:00	<p style="text-align: center;">"New Insights into Student Understanding of Electric Circuits"</p> <p style="text-align: center;">MacKenzie R. Stetzer Department of Physics, University of Washington Tranquility Room</p> <p>New insights into student understanding of electric circuits have emerged from an ongoing investigation by the Physics Education Group at the University of Washington. The investigation is part of a larger effort to develop and refine research-based instructional materials on electric circuits for several different student populations. The insights gained from this research have strong implications for instruction in a variety of contexts, including introductory physics courses and special physics courses for preservice and inservice teachers.</p>

3:00 - 3:15 - Break - Tranquility Room

3:15 - 4:25 Session B (Concurrent with Session C) - Tranquility Room

Session Chair: Ken Eckstein

3:15 - 3:30 - B1

Science Museum at Principia College. David Cornell, Principia College, Elsah, IL 62028. When the science departments moved from an old to a new building, space was preserved for a science museum. But there was no individual designated to design the space, nor was time released for the project. Retirement provided the stimulus and time to do the work. This talk tells the story of how one physics retiree engaged the science faculty in the process of setting up displays that culminated in a grand opening in April 2005.

3:30 - 3:45 - B2

Are Student-Designed Labs Effective in Teaching Physics Content? Zak Knott, Riverside-Brookfield H.S., Riverside, IL 60546. Over the past 20 years the concept of a student-designed lab has moved from relative obscurity to common practice in many classrooms. It is generally accepted that they are "good" for students, but there is very little research about their actual effectiveness in helping students understand content. I will present some findings from research conducted in my own classroom.

3:45 - 4:00 - B3

Ordering Investigations of Carbon Nanotubes over Organic Molecule Monolayers by Atomic and Magnetic Force Microscopy. Daniel K. Pratt, James Matthew Kerr, Saleem G. Rao, and Mark S. Boley, Western Illinois University, Macomb, IL 61455. Single walled carbon nanotubes (SWCNT) were placed on surfaces of bare SiO₂, on bare Au over the SiO₂, and on thin films (monolayers) of polar organic molecules including 2MI, cysteamine, and MHA that were molecular stamped over the Au surfaces. The organic monolayers were prepared such that there were periodic strips of four micron width (molecular stamping) of a hydrophobic molecule known as ODT, and the 2MI, cysteamine, or MHA (polar organic molecules) were in adjacent strips of 2 microns. Atomic Force Microscopy (AFM) pictures revealed that the SWCNT align themselves mostly in the polar organic molecular regions. Magnetic Force Microscopy (MFM) pictures revealed that the stamped samples exhibited periodic regions of vastly different magnetization levels, leading us to believe that ferromagnetic ordering is taking place amongst the polar organic molecules and the SWCNT that also seem to assemble and order themselves in their vicinity.

4:00 - 4:25 - Take Fives

1. *Cliff Parker*, "Palm Pipes"
2. *David Renneke*, "Ring Launcher Variations"
3. *Curt Hieggelke*, "Short Demo of the new WDSS"
4. *James Rabchuk*, "Physics Teacher Summer 2006 Workshop at WIU"
5. *Cecilia Vogel*, "SPS Zone 9 meeting hosted by Augustana - Apr. 21-22"

* Indicates participation in the Student Research Symposium. Namely, papers C1-C7

3:15 - 5:05 Session C (Concurrent with Session B) - 212C and 212D

Session Chair: Marty Potts

3:15 - 3:30 - C1

* **Designing a Two-Disk Ion Trap.** *Keith Pelletier and James Rabchuk*, Western Illinois University, Macomb, IL 61455. Ion traps are able to suspend individual ions in free space for an indefinite period of time. As such, they are ideal tools for studying properties of individual ions, for mass spectrometry and perhaps, in the future, for use in quantum computers. Ion traps work by producing a radio-frequency electromagnetic field which creates a ponderomotive trapping potential at the point where the field amplitude is weakest. In this presentation, several variations of a particularly interesting trap design, the two disk trap, and their effects on the pseudopotential will be presented. The role of a nearby grounded surface will be investigated, as well as the effect of other variations in the trap design. The accuracy of the numerical solutions of the fields and trapping potential will be explored. Simulations of ion behavior in these traps will also be presented. Plans for future investigations will be discussed.

3:30 - 3:45 - C2

* **Automated Calculation of Fractal Dimension of Congressional Districts.** *Nicholas Jurasek, B.K. Clark, Daniel Holland*, Illinois State University, Normal, IL 61761. The goal of this research is to create a computer program to automatically calculate the fractal dimension of congressional districts. It is obvious by simply looking at a map of Chicago that Gerrymandering occurs, however it is rather difficult to prove. This project aims to put a quantifiable dimension on a Gerrymandered district. In the presentation I will describe the steps taken to create the program to do this as well as some interesting preliminary results. I will also outline future goals of the project.

3:45 - 4:00 - C3

* **Ensemble vs. Frequency Averages for a Random Scattering Medium***. *Matthew Narter, S. Menon, Q. Su and R. Grobe*, Intense Laser Physics 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 [1-3]. 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 [4]. The calculation of the usual Boltzmann scattering coefficient from microscopic parameters can be improved to permit a better agreement with the exact Maxwell data [5]. 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.

4:00 - 4:15 - C4

* **Experiments of Light Scattering in Milk***. *Sawyer Campbell, G. Rutherford, B.K. Clark, Q. Su and R. Grobe*, Intense Laser Physics Theory Unit at 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.

4:15 - 4:30 - C5

* **Monte-Carlo Simulations for Light Scattering in Milk***. *Alison O'Connell, S. Menon, Q. Su and R. Grobe*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790-4560. We inject an angularly collimated laser beam into a scattering medium of a non-dairy creamer-water solution and examine the distribution of the scattered light along the optical axis as a function of the source-detector spacing. The experimental and simulated data obtained from a Monte Carlo simulation suggest four regimes characterizing the transition from un-scattered to diffusive light. We compare the data also with theoretical predictions based on a first-order scattering theory for regions close to the source, and with diffusion-like theories for larger source-detector spacings. We demonstrate the impact of the measurement process and the unavoidable absorption of photons by the detection fiber on the light distribution inside the medium. We show that the range of validity of these theories can depend on the experimental parameters such as the diameter and acceptance angle of the detection fiber. *Supported by grants of the NSF, Research Corporation, Illinois State Honors Program.

4:30 - 4:45 - C6

*** Classical Model to Understand the Pair Creation Process***. *Nic Chott, Q. Su and R. Grobe*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790-4560. Using a simplified model systems we examine the production of an electron-positron pair in a spatially localized force-field [1-4]. Using numerical solutions to computational quantum field theory we compute the kinetic energy spectra of the created particles. A comparison with classical mechanical calculations based on simple trajectories suggests that despite the fully relativistic and quantum mechanical nature of the matter creation process, some aspects can be understood very well in terms of classical mechanics. This approach also permits us to distinguish between the energies that the particles are born with and those energies they gain by accelerating out of the force field. *Supported by grants of the NSF, Research Corporation, Illinois State URG and Honors Program.

4:45 - 5:00 - C7

*** Reconstruct Embedded Images Using Transmitted Light***. *Tim Garvin, Q. Su and R. Grobe*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790-4560. We show that in the regime where the traditional diffusion theory breaks down for a highly modulated source, with modulation frequencies (\gg GHz) only the ballistic and quasi-ballistic photons survive. This regime becomes accessible for imaging applications. We develop an iterative quasi-analytical scheme to compute the radiance transmitted from a thin plane parallel layer of turbid media illuminated by high frequency intensity modulated light. We compare the spatial distribution of the transmitted signal obtained from iterative calculations with that obtained from numerical random walk simulation. *Supported by grants of the NSF, Research Corporation.

5:00 - 5:05 - Take Fives

1. *Cecilia Vogel*, "SPS Zone 9 meeting hosted by Augustana - Apr. 21-22"

5:05 - 5:30 - Free Time

5:30 - 6:00 Social time - cash bar open in **Quail Meadows**

6:00 - 7:00 Banquet - Quail Meadows
Presentation of the *Outstanding High School Physics Teacher Award* to Troy Gobble.

7:00 - 9:00	<p><i>"Implementing Research Based Instructional Materials in the Physics Classroom: From the Introductory Physics Class to a Course for the Professional Development of Teachers"</i></p> <p>Mel Sabella Department of Chemistry and Physics, Chicago State University Quail Meadows</p> <p>Physics education researchers have learned a great deal about students' knowledge and have developed many instructional environments to help students resolve robust conceptual difficulties. Often, the difficulties students possess in high school persist in college, and for many students, they persist after one or more years of college level physics. In order to address some of these issues the Physics Program at Chicago State University is engaged in two major projects to address the needs of teachers and students in the high schools as well as the students in the introductory physics classes at a comprehensive urban institution. In this talk I describe these programs and highlight some of our successes and challenges.</p>
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Saturday, April 8, 2006

7:30 - 8:30 ISAAPT Council meeting - Presiding: Bill Hogan, President, ISAAPT. Main Building, Room 211A

8:00 - 10:00 Registration - Main Building, Room 317A. Please make out your checks to "ISAAPT".

* Indicates participation in the Student Research Symposium. Namely, papers D1-D4

8:30 - 9:30 Session D - 319E

Session Chair: Ken Eckstein

8:30 - 8:45 - D1

* **The Relation of Gender and Age to the Dominant Frequency Ratio of the Human Voice.** *Harrison Bralower, Hans Muehler*, Naperville Central High School, Naperville, IL 60540. Voice samples from six age groups and both genders were collected using a sound sampling and analysis program. The resulting data was analyzed in an effort to determine what the ratio of female to male dominant voice frequencies is. A further analysis was conducted to learn if this ratio was constant across age groups. The results of this study and possible future applications will be presented.

8:45 - 9:00 - D2

* **Investigating Conformal Stability of the HIV Envelope Protein gp120 with Molecular Dynamics Simulations.** *Christopher Glosser, Joe Beuckman*, Southern Illinois University Edwardsville, Edwardsville, IL 62026. We run molecular dynamics simulations in order to characterize conformational changes in the HIV envelope glycoprotein gp120, the molecule that the AIDS virus uses to infiltrate human T-Cells. Presently, we discuss our hardware configuration issues, and the data manipulation necessary in order to locate flexible strands of the protein. Once these are identified, future calculations will use steered molecular dynamics (SMD) to examine the flexibility of the molecule. In this work, we present preliminary results, including animated visualizations of our simulations.

9:00 - 9:15 - D3

* **The Effects of the Una Corda Pedal on Harmonic Structure.** *Danielle Castens, M. L. Horner and Rebecca Lindell*, Southern Illinois University Edwardsville, Edwardsville, IL 62026-165. Pianists use the una corda pedal on the grand piano not only to decrease the volume but also to produce a more subdued tone, which is a change in sound quality. There are two possible elements that may be affected: loudness and harmonic structure. This study seeks to determine whether sound quality is altered with the use of the una corda pedal by comparing the harmonic structures of pitches played with and without the una corda pedal. Results of this study will be presented.

9:15 - 9:30 - D4

* **Examining the Interrelationships of Size, Sensitivity, and Domain Wall Profiles in ESR-420 Steel Torque Transducers .** *Matthew W. Beckner, Daniel K. Pratt, Jason T. Orris, and Mark S. Boley*, Western Illinois University, Macomb, IL 61455. Solid and hollow sensory shafts were fabricated from ESR 420 steel for application as torque transducers with diameters ranging from 18 mm down to 5 mm. Next, the measurement of torque load sensitivity was conducted for the transducer by the circumferentially polarized magnetization of two small regions near the center of the shaft in opposing directions and collecting the magnetic signal emanating from the separating domain wall as torque was applied and then removed. The observed sensitivities were found to first improve, but then later significantly degrade, as we continued to decrease the shaft diameter. The technique of magnetic force microscopy (MFM) was then used to examine the profiles of the center domain wall in the torque sensor section of each shaft, and by fitting the sequential MFM scans we were able to directly measure the domain wall width and height for each sample.

9:30 - 9:45 - Break - 317E

9:45 - 10:15	<p>"The Road Less Traveled: Reflections of a Physics Teacher Educator"</p> <p>Carl Wenning Coordinator, Physics Teacher Education Program, Illinois State University Tranquility Room</p> <p>In 1994 I became coordinator of the Physics Teacher Education program at Illinois State University. Since that time I have seen the program grow from essentially one course and five majors to six courses and more than 40 majors. Having no formal preparation as a teacher educator, I began my journey down the road with the best of intentions and little experience. I have since traveled far down the path as physics teacher educator, and have learned a lot of things along the way. This presentation will deal with my education as a high school physics teacher educator, and what conclusions I have drawn after reflecting on nearly a dozen years of experience.</p>
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10:15 - 10:30 - Break - 317E

10:30 - 11:35 Session E - Faculty Papers - 319E

Session Chair: Ken Mellendorf

10:30 - 10:45 - E1

Replacing Textbook Examples With Activities. *Bill Hogan*, Joliet Junior College, Joliet, IL 60431. One change I have made to my first semester calc-based physics course recently is to replace some of the textbook example problems I have lectured on in the past with hands-on activities. The activities require students to do numerical calculations similar to what was done in the example problems in past years. I will discuss some of the activities involving circular motion, energy conservation, and momentum conservation that I believe students have enjoyed and learned from.

10:45 - 11:00 - E2

Physics of Finance Course. *Benjamin L. Brown*, Principia College, Elsah, IL 62028. Our Physics of Finance course concentrates on financial derivatives which are securities that derive their value from an underlying security such as a stock, foreign currency, or market index. The course is designed for the non-science majors. The students open practice on-line trading accounts and learn standard technical analysis before proceeding to equity options (derivatives). Calls, puts, spreads, straddles, strangles, and butterflies are examples of derivatives, and derivative combinations, that are studied. Harvard educated Fisher Black, who had degrees in physics and math, is the father of modern derivatives markets. A geometric Brownian motion model of stock prices leads to the famous Black-Scholes pricing model. The Nobel Prize in Economics was awarded to in 1997 for this pioneering Black-Scholes model.

11:00 - 11:15 - E3

Experimental Positron Physics: Undergraduate Teaching Tool. *D.B. Cassidy, S.H.M Deng, R.G. Greaves, T. Maruo, N. Nishiyama, J.B. Snyder, H.K.M. Tanaka, and A.P. Mills, Jr.*, Principia College, Elsah, IL 62028. At Principia College the development of a low energy positron beam has proven to be an outstanding teaching tool for experimental physics. During undergraduate study, students learn a lot of classroom theory in E/M, quantum, nuclear, classical, solid state and statistical physics. Experimental positron physics provides students the opportunity to get into the lab and apply that theory. In the positron lab, students learn about vacuum systems, trapping charged particles, and electronic control/detection systems. This foundation allowed me to immediately contribute with the positron physics group at UC Riverside over the summer. This work resulted in a PRL publication "Experiments with a High-Density Positronium Gas." Work continues on Principia positron beam where I am a graduate research intern. This presentation will focus on the value that applied studies have had for my undergraduate education.

11:15 - 11:35 - Take Fives

1. *Ken Mellendorf*, "Using TIPERs"
2. *Benjamin Brown*, "Check Zero Grading System"
3. *Dave Sykes*, "Important Physics Words -- Survey Results"
4. *Lenore Horner*, "Torque"

11:45 - 12:45 Lunch - Tranquility Room. *It must be ordered with registration.*

General meeting for the presentation of awards for the Student Research Symposium.