Spring 2015 Meeting of the APS New England Section
Boston, Massachusetts
http://www.aps.org/meetings/meeting.cfm?name=NES15
online course. Course development has been supported by Boston University’s Digital Learning Initiative, as well as by a grant from edX.

January, we have been teaching an online course on edX, called Preparing for the AP Physics 1 Exam. As it sounds, the course is designed to prepare high school students for the AP Physics 1 exam in early May. However, covering basic introductory physics, the course has also attracted a wide variety of students from around the world. Topics covered in this talk include statistics regarding student demographics and student involvement as the course has progressed; examples of the online labs we have set up, many based on direct-measurement videos or HTML5 simulations - this is aimed at the requirement that 25% of the course be lab-based; and a discussion of our experiences teaching an online course. Course development has been supported by Boston University’s Digital Learning Initiative, as well as by a grant from edX.

2:45PM A1.00002 Evolution of teaching at an undergraduate college. JEFF WILLIAMS, Bridgewater State University — At Bridgewater State University, I have been making significant changes specifically to two courses. I along with another professor have changed our introductory physics course from a standard lecture/lab to a studio-style course using a NSF STEP grant. The Energy and Society course, one of the popular science core requirements, was a face to face course for many years. I moved it to an 80/20 web course, then to 100% on-line and now I am flying book free 100% on-line. I will talk about the development of the two courses and along the way intermingle the talk with observations about being a professor at a primarily undergraduate university.

3:15PM A1.00003 COFFEE BREAK –

3:30PM A1.00004 The future of STEM education: Preparing the next generation of faculty. BENNETT GOLDBERG, Boston University — More than 80% of future STEM faculty that will teach the next generation in the 4,500+ institutions of higher education in the US receive their PhDs at fewer than 100 institutions. Preparing graduate students and postdocs now to use evidence-based instruction, active-learning, and effective teaching practices can change the future of higher education. We discuss the model of the Center for the Integration of Research Teaching and Learning (CIRTL) Network, a coalition of 22 universities preparing future faculty. To scale and reach the more than 43,000 STEM PhDs that graduate each year and 20,000 that take postdoctoral positions, we created the model of the Center for the Integration of Research Teaching and Learning (CIRTL) Network, a coalition of 22 universities preparing future faculty.

4:00PM A1.00005 Atomic and Molecular Separation through Porous Graphene. SCOTT BUNCH, Boston University — Graphene, a single layer of graphite, represents the first two-dimensional atomic crystal. It consists of carbon atoms covalently bonded in a hexagonal chicken wire lattice. This unique atomic structure gives it remarkable electrical, mechanical, and thermal properties. However, it is the mechanical properties of this material that fascinate our group the most. It is the thinnest and strongest material in the world as well as being impermeable to all standard gases. This high strength, extreme flexibility, and unprecedented barrier properties make graphene an intriguing material for membrane based filtration. Graphene acts as a barrier for gases and liquids and represents the thinnest membrane possible (one layer of atoms) with the smallest pore sizes attainable (single atomic vacancies), and unprecedented mechanical stability. In this talk, I will review our experimental work on gas and liquid ion transport through angstrom sized pores in suspended porous graphene membranes. These measurements help elucidate the fundamental molecular and ionic transport mechanisms in this unique material.

4:30PM A1.00006 System-Level Applications of Two-Dimensional Materials: Challenges and Opportunities. TOMAS PALACIOS, Massachusetts Institute of Technology — Two-dimensional materials represent the next frontier in advanced materials for electronic applications. Their extreme thinness (3 or less atoms thick) give them great flexibility, optical transparency and an unsurpassed surface-to-volume ratio. At the same time, this family of materials has tremendously diverse and unique properties. For example, graphene is a semimetal with extremely high electron and hole mobilities, hexagonal boron nitride forms an almost ideal insulator, while MoS2 and other dichalcogenides push the limits on large area semiconductors. The growth of these materials over large areas has allows their use in numerous system-level demonstrators. For example, the zero bandgap of graphene and its ambipolar has been used in a wide variety of rf and mixed applications, including frequency multipliers, mixers, oscillators and digital modulators. At the same time, the wide bandgap of MoS2 in combination with advanced fabrication technology has enabled its use in memory cells, analog to digital converters and ring oscillators with orders of magnitude better performance than other materials for large area applications. These and other examples will be discussed to highlight the numerous new opportunities of 2D materials.

5:00PM - 5:00PM –

Session B5 Poster Session  Hariri Institute for Computing -
B5.00002 Tunneling conductance in graphene ferromagnet/ superconductor junctions at finite temperatureootnote{This work was supported by the National Natural Science Foundation of China under Grants No. 11074088}, XIAOWEI LI, Huiyin Normal University — Using the extended Blonder-Tinkham-Klapwijk formalism, we investigate the conductance spectra of graphene ferromagnet / p wave superconductor junctions at finite temperature. It is found that the conductance spectra at finite temperature are affected by the p wave pairing symmetry. The ferromagnetic exchange energy in the ferromagnet can suppress Andreev retroreflection but enhance the specular Andreev reflection in graphene ferromagnet / p wave superconductor junctions at finite temperature.

B5.00003 Ionic transport across porous graphene membranes, LAUREN CANTLEY, SCOTT BUNCH, Boston Univ — Graphene is an attractive material for applications in single molecule sensing and molecular sieving, in part due to its atomic thinness, strength and barrier properties. In this study, we examine ionic transport across a suspended single-layer graphene membrane separating two reservoirs of aqueous ionic solution. Molecularily sized, sub-nm pore(s) are introduced by chemical etching, which allow for only proton transport across the graphene membrane. The pore is further opened and ionic conductance measurements are carried out to further investigate and characterize ionic transport across sub-nm and nm-scale pores.

B5.00004 Charge Density Waves in Metal-Intercalated Topological Insulator Nanoribbons, JEFFREY COMMONS, Brown University — Topological insulators are an exciting new form of matter in which the interior is insulating while the surface supports symmetry-protected conductive states. We report on charge density wave transitions in the two-dimensional layered topological insulator bismuth selenide (Bi2Se3) following intercalation with zero-valent metals. Using a previously reported intercalation method, Bi2Se3 nanoribbons were intercalated with either one or a combination of two metals. Disorder-order polypytic phase transitions were subsequently observed with in-situ transmission electron microscopy. In particular, nanoribbons intercalated with both copper and iron demonstrate a superlattice at room temperature indicative of a charge density wave stabilized by intercalant ordering; heating of these nanoribbons to $\sim 375 \, ^\circ \text{C}$ introduces several disorder-order phase transitions, which demonstrate varying degrees of reversibility on subsequent cooling.

B5.00005 Connecting electron and phonon spectroscopies to consistently determine quasiparticle-phonon coupling on the surface of topological insulators, COLIN HOWARD, MICHAEL E-L BATANOUNY, Boston University — Photoemission and phonon spectroscopies have yielded widely varying estimates of the electron-phonon coupling parameter $\lambda$ on the surfaces of topological insulators, even for a particular material and technique. We connect the results of these experiments by determining the Dirac fermion quasiparticle spectral function using information from measured spectra of a strongly-interacting, low-lying optical surface phonon band. The manifest spectral features resulting from the coupling are found to vary on energy scales $< 1 \, \text{meV}$, and are distinct from those traditionally observed in the case of acoustic phonons in metals. We explore different means of determining $\lambda$ from the electron perspective and identify definitions that yield values consistent with phonon spectroscopy.

B5.00006 Symmetry Breaking and Friction in Phosphorene, JASON CHRISTOPHER, Boston University, STEVEN KONEN, National University of Singapore, ANGELO ZILETTI, Boston University, BO WEN, HAN ZHENG, CORY DEAN, Columbia University, OZYILMAZ BARBAROS, National University of Singapore, ANNA SWAN, BENNETT GOLDBERG, Boston University — Strain in 2D crystals tunes material properties, controllably breaking crystal symmetry, and inducing pseudo magnetic fields. Friction plays a central role in these applications because of its effect on the strain field’s orientation and magnitude. We have developed a simple experiment for generating known strain fields in 2D crystals to explore phonon response and friction. Our technique utilizes 2D crystals suspended over holes etched in a Si substrate to create sealed micro-chambers. We place these chambers into a pressure vessel with an optical window for Raman measurements while simultaneously applying external pressure. The pressure deforms and slides the 2D material into the hole, and we map out the strained Raman spectra. The Raman active phonons of phosphorene in the backscattering configuration are the A$^g$, B$^g_{2y}$ and A$^g_2$ modes. Group theory predicts that these modes are non-degenerate, however as we strain the material we observe peak splitting, which is attributed only for degenerate modes. This apparent discrepancy can be explained by considering the effect of strain on the Raman selection rules. Under strain the crystal symmetry is broken causing previously Raman inactive modes to become active creating an effect that appears like peak splitting.

B5.00007 Site-directed Fabrication of High-quality Transfer-free Freestanding 2D Membranes, PRADEEP WADUGE, JOSEPH LARKIN, ISMAIL BILGIN, Northeastern University, ADAM GRAHAM, Harvard University, KENNETH GOODFELLOW, CHITRALEEMA CHAKRABORTY, NICK VAMIVAKAS, Rochester University, MONEESH UPMANYU, SWASTIK KAR, MENI WANUNU, Northeastern University — We present an approach for direct growth of freestanding graphene and molybdenum disulfide (MoS2) membranes across pre-fabricated solid-state apertures. The freestanding 2D membranes are directly grown over microscale apertures in SiN membranes using chemical vapor deposition apparatus under appropriate temperatures and pressures. The 2D membranes grow preferentially over apertures, resulting in sealed membranes that are one to a few layers thick. The mechanisms by which these growths occur are investigated, which favor aperture-limited growth. The membranes are shown to be of great quality by atomic-resolution transmission electron microscopy, Raman spectroscopy, and photo luminescence spectroscopy. In addition, we demonstrate low-noise ion-current recordings through nanopores fabricated in such membranes. Finally, we highlight the functionality of these devices by measuring DNA translocations through nanopores in such membranes.

B5.00008 Online Tutorial Video Experiments, NORMA CHASE, MCPHS University - Boston, School of Arts and Sciences — During Spring 2015, online tutorial video experiments provided students with valuable experience with the motion of charged particles in uniform electric fields. Firstly, the visual aspect of “movies” helped to bring the physics to life for many students, as did other simulation videos used as lecture demonstrations and homework. Further, students were required to produce lab reports clearly and completely demonstrating the reasoning behind all of their predictions. Online postings of Sample Data Sheets and Sample Predictions pages provided significant guidance to this end, and students were required to submit their video “lab reports” for rigorous grading. Based on preliminary data, it appears that the experience produced learning gains beyond that typically achieved by solving “standard” text book homework problems.
Disciplinary engagement in an online learning environment, LAMA JABER, VESAL DINI, DAVID HAMMER, ETHAN DANEHY, Tufts Univ — This poster describes middle school science teachers’ progress in scientific inquiry in a Tufts University blended online course (complemented by periodic in-person meetings). Here, we focus on the shift that took place in teachers’ participation, moving from following instructions to animating their own inquiry. This shift, we argue, was supported by a responsive teaching approach that put their thinking at the center, and by a flexible digital platform called InterLACE (“Interactive Learning and Collaboration Environment”) that facilitated collaborative knowledge-building and evolution of the online learning spaces. More specifically, InterLACE enabled us to change the online course structure from what we implemented over the first four weeks, to one co-constructed with participants thereafter. We see this as a primary catalyst for their disciplinary engagement and ownership of learning.

The Effect of Person’s Height on Projected Soccer Ball Throw, ALICE O’CONNOR, KIMBERLY FARAH, Lasell College, DIPTI SHARMA, WIT — In this project, undergraduate science minors applied the concept of projectile motion to soccer. They explored the effect of person’s height on a soccer ball’s projectile motion. Does the height of a person change the range of the soccer ball? In soccer the term “follow through” is applied to situations when the ball is kicked. Follow through refers to the distance the leg travels after the ball is kicked. The idea is that the more a person follows through, the less height and greater distance the ball will travel. The dependent variable is the measured force. The controlled variables were the length of the stick. Kinematic data was collected using a motion detector and the graphical analysis software logger pro. Then, force was calculated following Newton’s second law for each shot. Also power and work produced were calculated.

Physics of a Lacrosse Shot, JORGE SALAZAR, KIMBERLY FARAH, Lasell College, DIPTI SHARMA, WIT — This experiment focused on the application of Newton’s second law for determining the force placed on a lacrosse ball as a function of player weight. If a lacrosse player shoots a ball using a stick into a goal, the force can be calculated. For this experiment we tested a lacrosse player weight. If a lacrosse player shoots a ball using a stick into a goal, the force can be calculated.

Cheerleading and Dance Jumps, JAZMINE JOHNSON, KIMBERLY FARAH, Lasell College, DIPTI SHARMA, WIT — This undergraduate project was “Do different types of footwear have an effect on the overall velocity and acceleration generated by someone sprinting?” The independent, dependent and control variables were the types of shoes, time to cover a certain distance, and the distance required to sprint and the environment. A set distance (21.3m) was used for each trial. Velocity and acceleration were calculated using logger pro software. The collected data were analyzed by logger pro and found significant differences in the types of shoes.
viscosity reduction we observed or the criteria for the existing mechanisms need to be revised.

allow for constraint release of the Edwards tube, respectively. Our result suggests that either an unaccounted mechanism exists in causing the be smaller than the matrix $R$

the ratio of the molecular weight of the homopolymer, $P$, to that of the ligands, $N$, is bigger than 1. Importantly, the phenomenon of viscosity reduction, contrary to Einstein’s prediction, was observed or the criteria for the existing mechanisms need to be revised.

KUMAR’S GROUP TEAM — We studied the viscosity of polymer nanocomposites (PNC) containing silica nanoparticles (core radii, $g$) is bigger than the matrix $R$ and also the Edwards tube diameter – fulfillment of which means that the particles may act as a plasticizer and exhibit corkscrew motion while swimming.

Maira Constantino, Joseph Hardcastle, Ramas Banisl, Boston University — Helicobacter pylori is a spiral shaped bacterium associated with ulcers, gastric cancer, gastritis among other diseases. In order to colonize the harsh acidic environment of the stomach $H. pylori$ has to go across the gastric mucus layer. Many studies have been conducted on the swimming of $H. pylori$ however none have studied the trajectory path. We present a single cell experimental study of the effects of body shape in the swimming trajectory of $H. pylori$ in pig gastric mucus and liquid media by a quantitative analysis of the bacterium’s rotation and translation using phase contrast microscopy and particle tracking techniques while simultaneously measuring the bacterium’s body parameters. Our measurements show very well defined helical trajectories, from which we measure the body rotation.

1Supported by the National Science Foundation PHY PoLS

Oscillations from ARCTIC WARMING: Record Cold & Hot, RISING SEAS — Paul H. Carr,退休 — Both weather extremes and global sea levels have been increasing. In New England, the winter of 2015 had record snowfall and cold temperatures. The West had temperatures of 100 deg. F. Polar vortices in the jet stream explain this (1). This stream used to be confined to the Arctic by the large temperature and pressure differences between the North Pole and the rest of the earth. In recent decades, the Arctic has warmed twice as fast as the rest of the earth. This lower temperature and pressure difference results in the jet stream’s sinusoidal pattern. In some locations, cold polar air oscillates as far south as New Orleans. In other places, hot tropical air comes further north. Global sea levels are presently rising up to four times faster than in 1900. These rates extrapolate to sea level rises of 2 to 6 feet by 2100. Sea level rises of 2 to 4 feet will flood the Boston’s Back Bay, including Boston University. I will show that the increasing sea level rise correlates with the increasing carbon dioxide levels. Thus, sea level rise is a better measure of global warming than temperature.


Feynman diagrams interpreted by the Theory of Elementary Waves (TEW) — Jeffrey Boyd, Retired — Feynman diagrams are interpreted as pictures of elementary rays. The Theory of Elementary Waves (TEW) is unknown to most physicists. It is the only local realistic picture of the quantum world that is consistent with the Bell test experiments. Like quantum mechanics, TEW violates the Bell inequalities, but unlike QM, TEW is local and realistic. It is neither the Einstein hidden variable nor the Wheeler-Feynman absorber theory. Apparently we live in an ocean of zero energy elementary waves, about which we know almost nothing. We seek a picture of the world of elementary rays, using quantum mathematics as our guide. Feynman diagrams provide the pictures we seek. Such diagrams are not supposed to be pictures of reality. Rather the Feynman tradition says we should integrate across all Feynman diagrams to calculate the overall probability amplitude of a superposition. However we violate the rules and take them as pictures of reality. TEW sounds preposterous to many. Thomas Kuhn reminds us that the major paradigm shifts in science sounded preposterous to scientists of previous decades. TEW involves a MAJOR paradigm shift in both quantum and classical physics.

Viscosity of Polymer Nanocomposites with Athermal Hairy Nanoparticles — Fei Chen, Physics Department, Boston University, Dan Zhao, Sanat K. Kumar, Department of Chemical Engineering, Columbia University, Opheilia K. C. Tsui, Physics Department, Boston University, Prof. Opheilia K. C. Tsui’s Group Team, Prof. Sanat K. Kumar’s Group Team — We studied the viscosity of polymer nanocomposites (PNC) containing silica nanoparticles (core radii, $r_c = 4.12$, and 25 nm) grafted with polystyrene ligands blended with polystyrene homopolymer. Viscosity reduction, contrary to Einstein’s prediction, was observed in the PNCs fulfilling the following conditions: (1) The radius of gyration of the matrix polymer ($R_g$) is bigger than the $r_c$ and (2) the ratio of the molecular weight of the homopolymer, $P$, to that of the ligands, $N$, is bigger than 1. Importantly, the phenomenon of viscosity reduction we observed is unlike those observed previously. Specifically, previous observations had found the diameters of the particle inclusions to be smaller than the matrix $R_g$ and also the Edwards tube diameter – fulfillment of which means that the particles may act as a plasticizer and allow for constraint release of the Edwards tube, respectively. Our result suggests that either an unaccounted mechanism exists in causing the viscosity reduction we observed or the criteria for the existing mechanisms need to be revised.
B5.00022 Stigmatic Imaging of Dielectric Nanoparticles in High Refractive Index Object Space, YANG GELLY, Boston University, Physics Department, STEVEN SCHERR, Boston University, Mechanical Engineering Department, DERIN SEVENLER, Boston University, Biomedical Engineering Department, SELIM UNLU, Boston University, Electrical Engineering Department, BENNETT GOLDBERG, Boston University, Physics Department — Dielectric nanoparticles do not lend themselves readily to popular superresolution and high-contrast techniques due to their non-resonant behavior, so more traditional optical approaches are necessary for their imaging. We explore some methods in classical optics to boost both the measured optical signal from these particles while simultaneously pushing the resolution limit past $\lambda/2.5$, even with modest objective lenses (NA$=0.45$). The two principal technologies that allow for such imaging are an interferometric reflectance imaging substrate (IRIS) and a solid immersion lens (SIL) with access to its aplanatic focal point. We have characterized contrast and resolution using two parameters: the object space immersion medium refractive index and the relative index of the particle to the medium. At this conference, we will be presenting a simple physical model to describe how contrast and resolution should scale with these parameters, and then we will share imaging data for comparison. Additionally, we will discuss the methods and challenges of working with IRIS and SIL's in a research setting.

B5.00023 ABSTRACT WITHDRAWN

B5.00024 Magnetic Resonance Imaging on Cardiovascular System for Scanned Image Quality Improvement, RICHARD KYUNG, HWANKYU SONG, JEONG H. (PETER) YOON, CRG-Choice Research Group — Magnetic Resonance Image is one of the most widely used technologies to detect, diagnose, and study various diseases. However, there exist some drawbacks to the technology, such as ringing artifact and long scanning time. The purpose of the present research is to develop a more efficient low pass filter or filter function, in order to increase the resolution of the scanned image, decrease the Ringing Artifact, and decrease the time required to contrast and image. We propose the image not a new filter or filter function, but a new subtraction method. Using this method, we corrected the distance for the distortion caused by the finite size of the electron, and then the resulting radius of the proton. This gives us $2\pi$, and is valid for the electromagnetic energy $E$.

B5.00025 Biophysical Analysis of Tibia Using Computational Simulations, WOOYOUNG CHO, JINPYO HONG, SEYOON OH, CRG-Choice Research Group — High compressive forces can cause severe stresses on the tibial bone. Repetitive loads applied to the upper surface of the tibial bone can lead to dangerous bone damage. To reduce the undesirable effect, the tibial bone and its joint need to be analyzed using biomechanical simulation before its empirical experiment. Mathematical and physical model of a two-dimensional bone model of the tibia is used to study bone stress and fracture analysis. In this paper, MRI scanning of the tibia was used to study the biological and mathematical methods. Computational approach to enhance the quality of the image was carried out for the analysis of various cases. Also, removal of ringing artifact in the magnetic resonance image using Fourier transform and mathematical morphology was presented. To improve the resolution of the tibia from low contrast MRI films, high pass filter and specific filter in MATLAB was used. Also, noise removal of the magnetic resonance image using Fourier transform and mathematical morphology was presented. To improve the resolution of the tibia from low contrast MRI films, high pass filter and redesigned filter were used, achieving a good tradeoff between the code running time and resolution of the MRI Image of the tibia.

B5.00026 The Vortex Electron and the Origin of the Bohr Radius and its Fine Structure Constant, and Pilot Wave, ERNST WALL, Institute for Basic Research, Palm Harbor, FL — We relate the first Bohr radius to the radius of a finite sized vortex electron whose charge revolves at the speed of light in a Compton wavelength orbit and produces the Bohr magnetron, identically. The revolving charge's impulses produce a spiraling electric field, or vortex, of Compton wavelets around the electron. A train of 43 Compton wavelets, n, emitted by the electron and reflected back from the nucleus, gives the Bohr radius = $r_B = \lambda/(2\pi)$, where $\lambda$ is a Compton wavelength of 43 Compton wavelets, n, emitted by the electron and reflected back from the nucleus. This gives us $r_B = 21.809394$ Comptons. Here $r_B$ is the radius of the proton. This gives us $z = 17.0325$ (25 ppm err). Here, $z$ is a correction factor of 1.00057126 from the combined potential well and reduced mass correction. We also correct the distance for the distortion caused by the finite size of the electron, and then the resulting improved constant is then $z = 17.03066$ (33 ppm error). We also claim the Compton wavelets are equivalent to the pilot waves sought after by de Broglie and Bohm. – References: www.twitchmodel.com, Ernst Wall, The Physics of Tachyons, Hadronic Press (1995), Ernst L. Wall, Bull of APS (1999).

B5.00027 Combining Citizen Involvement and Government Bureaucracy to Illumination the Memorial Bridge between New Hampshire and Maine with LEDs, PETER SOMMISICH, Illumination Committee, Portsmouth NH — The innovative design and construction of the new Memorial Bridge connecting New Hampshire and Maine has made headlines in respective professional publications. The contributions of the Public Advisory Committee, required by federal law for such projects, has not. A subgroup, the Illumination Committee, decided that this bridge needs some enhancement to make it not only functional but as pleasing to the eye as possible. They proposed an illumination design for the bridge and raised $250,000 to successfully implement their design and construction. In this paper, a nonconventional approach and a new filter function were proposed and tested on the cardiovascular system image and computer running time.

B5.00028 Incompleteness of General Relativity, Einstein's Errors, and Related Experiments, C.Y. LO, Applied and Pure Research Institute — General relativity is incomplete since it does not include the gravitational radiation reaction force and the interaction of gravitation with charged particles. General relativity is confusing because Einstein's covariance principle is invalid. There is no bounded dynamic solution for the Einstein equation. Gullstrand is right and the 1939 Nobel Prize for Physics press release is incorrect. Also, awards to Christodoulou reflect the blind faith toward Einstein and accumulated errors in mathematics. The Einstein equation with an electromagnetic wave source has no valid solution unless a photon energy-stress tensor with an anti-gravitational coupling is added. Thus, the photonic energy includes gravitational energy. The existence of anti-gravity coupling implies that the energy conditions in space-time singularity theorems of Hawking and Penrose cannot be satisfied, and are irrelevant. The positive mass theorem of Yau and Schoen is misleading, though considered as an achievement by the Fields Medal. $E = mc^2$ is invalid for the electromagnetic energy alone. The discovery of the charge-mass interaction establishes the need for unification of electromagnetism and gravitation and would explain puzzles. Experimental investigations for further results are important.
The square of any quaternion luckily has the Lorentz invariant interval of special relativity as its first term.

\[(dt, dx_1, dx_2, dx_3)^2 = (dt^2 - dx_1^2 - dx_2^2 - dx_3^2, 2dt dx_1, 2dt dx_2, 2dt dx_3)\]

The other three space-times-time terms are commonly ignored. Ways to vary a quaternion with a continuous function by leave the interval in the square invariant will be discussed. One method uses exponentials, leading to the hyperbolic functions found useful in special relativity. Using the same approach to keep the space-times-time invariant leads to a dynamic interval term. By preserving the space-times-time terms using an exponential function and the geometric source mass, an interval term is found that is similar but experimentally distinct from the Schwarzschild metric applied to space-time 4-vectors:

\[(e^{-z} dt, e^{z} dR_i/c)^2 = (e^{-2z} dt^2 - e^{2z} dR_i^2/c^2, 2dt dR_i/c)\]

\[= \left( e^{-2GM/c^2} dt^2 - e^{2GM/c^2} dR_i^2/c^2, 2dt dR_i/c \right)\]

\[\text{if } z = \frac{GM}{c^2 R}, \quad i = 1, 2, 3.\]

Space-times-time invariance is not a field theory, so gravitons are not necessary and quantization is moot.

B5.00030 From competitive exclusion to neutrality: A simple model of ecological dynamics exhibits rich collective behaviors. BEN DICKENS, Boston University — We study the dynamics of a simple stochastic model of interspecies competition in a small spatial patch (such as an island), surrounded by a regional pool of immigrating species. The model, introduced by Fisher and Mehta (PNAS 2014), describes when a species will be present or absent in the local community. For weak immigration rates, we vary the mean and variance of interspecies competition coefficients to uncover a rich variety of collective behaviors. If all interspecies competition coefficients are less than some critical value, then all species will achieve stable coexistence. On the other hand, if all competition coefficients are greater than this value, then the ecosystem exhibits a noise-dominated regime characterized by frequent invasions and extinctions by all species. In between, only some of the coefficients exceed this critical value and several dominant species emerge. These species remain in the local patch for almost all time, competitively excluding the other species that attempt, and fail, to invade. Remarkably, as the variance in competition approaches zero, these regimes meet a point in parameter space, a “Hubbell Point,” characterized by neutral dynamics. All of these claims are supported by analytic calculations and numerical simulation.

B5.00031 3-D Fluorescent Imaging of Fluid Flow in Rock, WILLIAM SHAIN, Physics Department, Boston University, HARI PAUDEL, THOMAS G. BIFANO, Mechanical Engineering, Boston University, BENNETT GOLDBERG, Physics Department, Boston University — Imaging deep inside porous media is a classical problem that manifests in enhanced oil recovery, geological CO₂ storage, and many other fields. However, the strong optical scattering from the pore structure limits traditional microscopy techniques to a few pore lengths from the surface. Superpenetration Multi-Photon Microscopy (S-MPM) is a technique to image through strongly scattering media by using coherent optimization of the phase front of incident light to compensate for the scattering in the material. We demonstrate that we can use S-MPM to create high-quality images of fluorescent beads through 40µm of calcite rock samples, and we plan to use our imaging capabilities to measure the flow characteristics of water and oil through porous rock.

Friday, April 24, 2015 7:45PM - 8:15PM –
Session C6 Invited Dinner Presentation by NES APS Hariri Institute for Computing Conference Room - Bennett Goldberg, Boston University

7:45PM C6.00001 Flat space, deep learning, ERIC MAZUR, Harvard University — The teaching of physics to engineering students has remained stagnant for close to a century. In this novel team-based, project-based approach, we break the mold by giving students ownership of their learning. This new course has no standard lectures or exams, yet students’ conceptual gains are significantly greater than those obtained in traditional courses. The course blends six best practices to deliver a learning experience that helps students develop important skills, including communication, estimation, problem solving, and team skills, in addition to a solid conceptual understanding of physics. This showcase will discuss the course philosophy and pedagogical approach and participants will take part in a new form of collaborative assessment.

Saturday, April 25, 2015 8:30AM - 9:30AM –
Session D1 Condensed Matter Physics Life Sciences and Engineering Building B01 - Colin Howard, Boston University

8:30AM D1.00001 Gd (III) doped LiMn2O4 cathode material for lithium ion rechargeable batteries, RAHUL SINGHAL, Department of Physics and Engineering Physics, Central Connecticut State University, New Britain, CT 06050, PURA RAM, RAKESH KUMAR SHARMA, Indian Institute of Technology Jodhpur, Jodhpur-India — The spinel structured LiMn2−xGdxO4 (x=0.01-0.05) have been synthesized via sol gel method. The physical and electrochemical characterization were carried out using X-ray diffraction (XRD), scanning electron microscopy (SEM), Energy dispersive x-ray analysis (EDX), Fourier transform infrared spectroscopy (FTIR), UV-Vis spectroscopy, Raman spectroscopy, cyclic voltammetry and charge-discharge studies. The reversibility of synthesized cathode was supported through cyclic voltammetry in 3.0 - 4.5 voltage range. The initial charge discharge capacity of cathode materials was found in range 130-140 mAhg⁻¹. The fabricated coin cell was tested up to 50 charge-discharge cycles with 0.5 C rate. The small amount of rare earth metal, Gd, doping showed improvement in capacity fading compared to LiMn2O4 cathode, offer its applicability for Li-ion rechargeable battery.
8:42AM D1.00002 Frequency Dependence of Dielectric Constant and Dielectric Loss in a-Se_{1-x}In_{x}Ag_2: CG glassy alloy. DIPTI SHARMA, Wentworth Institute of Technology, Boston, MA 02115, USA, S.K. SHARMA, R.K. SHUKLA, A. KUMAR, HBTI Kanpur, India — Amorphous chalcogenide glasses (CG) form the basis of re-writable CD and DVD solid-state memory technology. They exhibit thermally driven amorphous crystalline phase change which make them useful for encoding binary information on thin films of CGs and forms the basis of rewritable optical discs and non-volatile memory devices such as PRAM. CGs also show significant ionic transport that can be useful for data storage in a solid CG electrolyte. The present study shows the effect of frequency on dielectric parameters of an ionic CG of Se_{1-x}In_{x}Ag_2. They were measured in the frequency ranged from 200 Hz to 500 kHz and found to be decreased with frequency. The frequency dependence of dielectric loss can be explained in terms of Elliott’s model of correlated barrier hopping over a potential barrier [1-3].


8:54AM D1.00003 Quantum mechanical aspects of the decay of mechanical vibrations by electromagnetic radiation. ALLAN PIERCE¹, Retired — A body undergoing mechanical vibrations loses energy by electromagnetic radiation. If the vibrations are of a thermal nature, and if the body is surrounded by a medium such as air at a lower temperature, then the loss of energy is adequately described by the theory of radiative heat transfer, but mechanical vibrations are generally not associated with thermal equilibrium. The present paper argues that any good approximate account of the physical mechanisms responsible for radiative decay of mechanical vibrations requires some, perhaps modest, understanding of quantum electrodynamics. The analysis begins with the simple example of a molecule in its first excited vibrational state, with the objective of predicting the relaxation time for the decay to the ground state. It is noted that the overall theoretical framework developed by Weisskopf and Wigner (1930) gives the same overall result as the correspondence principle theory advanced somewhat earlier by Slater (1925), and the author consequently seeks to develop a general approximate theory based on the correspondence principle. It is shown in particular that the reciprocal of the relaxation time is a dimensionless quantity times the cube of the fine structure constant times the frequency of the electromagnetic emission.

¹Professor Emeritus at Boston University, Adjunct Professor at UMass Dartmouth, Institution Guest Scholar at WHOI, Visiting Research Scientist at RPI

9:06AM D1.00004 The basic physical principles involved in the conversion of vibrational energy to electrical energy in off-shore ocean wave energy systems. AMADOU THIAM, Boston University — While details of the currently most publicized devices for ocean wave energy conversion to electrical energy are generally not disclosed in the open literature, the author believes that, for devices not on the coastline, the common transduction mechanism involves electromagnetic induction with conducting wires moving relative to permanent magnets. A general discussion is given of how such a mechanism can be used in this application. The overall analysis of the mechanical system with lumped or distributed masses and elastic elements driven by buoyancy forces associated with incident ocean waves is facilitated, if the transduction system is modeled as linear mechanical dashpots, and the procedures for deriving effective dashpot constants are described. The analysis suggests that, for waves in a general frequency range, there is an optimal choice for the parameters of the mechanical system, so that the maximum electrical power can be harvested. The optimal energy extracted per wave cycle is invariably much less than the total mechanical energy of the oscillating components of the system. A distinction is made between freely floating systems and systems anchored to the ocean bottom and between systems driven near a resonant frequency and those driven substantially below resonance.

9:18AM D1.00005 Low Temperature D.C. Electrical Transport in Nsutite. PETER LEMAIRE, JONATHAN LEMBECK, JOHN DISTIN, Central Connecticut State University — This work attempts to shed some more light on earlier work in the naturally occurring manganese oxide Nsutite (Mn^{3+}, Mn^{2+}, O_{2-x}·(OH)_{2+x} where x = 0.06 - 0.07), that showed non-linear I-V response, and what seemed to be metallic to non-metallic behavior below 140 K. New data of four lead voltage measurements at constant current shows transient voltages below 140 K, and the results of the data analyzed to obtain the electronic conductivity data between 40 K and 140K. The significance of these measurements and results will be discussed.

Saturday, April 25, 2015 8:30AM - 9:30AM –
Session D2 Uponversion Physics

8:30AM D2.00001 Upconversion White, Blue and Red Emission from Yb^{3+}/Er^{3+}/Tm^{3+}: Y_{2}SiO_{5} nanocrystalline powders. OLGUN ERGUZEL, Istanbul Technical University, MURAT ERDEM, METE KAAN EKMEKCI, Marmara University, GONUL ERYUREK, Istanbul Technical University, BALDASSARE DI BARTOLO, Boston College — The generation of white light through up conversion under the excitation of infrared laser radiation may play an important role due to its potential application in the lighting and display applications. Bright white up converted emission has been observed in sol-gel derived Yb^{3+}/Er^{3+}/Tm^{3+}: Y_{2}SiO_{5} nanocrystalline powders when excited with the 950 nm emission of a laser diode. The International Commission on Illumination (CIE ) chromaticity coordinates (x, y) for YET1, YET2, and YET3 nano-powders in X_{2}Y_{2}SiO_{5} crystalline form were found to be (0.334, 0.332), (0.283, 0.292), (0.353, 0.345) for white, blue and red emission under 950nm laser diode excitation with the power of 1.5W, respectively. Interestingly, the color coordinates observed change with the doping concentration of Er^{3+}; hence the UC emission color can be adjusted by changing the doping concentration of Er^{3+}.

¹This study was financially supported by the Scientific Research Projects Unit (BAPKO) of Marmara University with the Project number FEN-B-150513-0170. One of the authors (Murat Erdem) would like to thank the TUBITAK
8:42AM D2.00002 Broad white light emission from sol-gel derived $\alpha$-Y$_2$Si$_2$O$_7$ nanoparticles activated with Yb$^{3+}$ and Er$^{3+}$ ions, JOSEPH LIGUORI, Boston College, MURAT ERDEM, Marmara University, BRYAN SITT, BALDASSARE DI BARTOLO, Boston College — We have observed white up conversion emission in sol-gel derived $\alpha$-Y$_2$Si$_2$O$_7$ nano-powders activated with ytterbium and erbium ions when excited with the 950 nm emission of a laser diode. The emission intensities of each Er$^{3+}$ transition decreased when the pumping power was increased from 1.7 to 2.5W with the observation of the bright wide band even at atmospheric pressure condition. When the sample was under very low pressure at 0.03 mbar and the pumping power was set from 0.9 to 2.5 Watt, the white emission brightness increased.

1This study was financially supported by the Scientific Research Projects Unit (BAPKO) of Marmara University with the Project number FEN-B-150513-0170. One of the authors (Murat Erdem) would like to thank TUBITAK for its support.

8:54AM D2.00003 Albert Bartlett and Implications of Exponential Growth, DAVID W. KRAFT, University of Bridgeport — Albert A. Bartlett, late Professor Emeritus of Physics at the University of Colorado, spent the latter half of his life alerting both the community of physicists and the world at large to the implications of unchecked exponential growth. Among the areas he addressed were population growth, sustainability and consumption of non-renewable resources. He placed particular emphasis on the concept of the doubling time in an exponential process, showing, for example, that the amount of a resource consumed in a doubling interval exceeds or is approximately equal to the total consumed in all of history prior to the start of that interval. We present here some examples contained in a typical Bartlett lecture or paper with the hope that, with his passing in 2013, a new generation of physicists will continue this educational effort.

9:06AM D2.00004 White wide-band emission from Yb$^{3+}$·Y$_2$Si$_2$O$_7$ nanoparticles under IR excitation, BRYAN SITT, Boston College, MURAT ERDEM, Marmara University, GAOZAN DING, Wheaton College, GONUL ERYUREK, Istanbul Technical University, BALDASSARE DI BARTOLO, Boston College — The spectral properties of Yb$^{3+}$ ions have attracted considerable attention and offered the possibility of obtaining an infrared emission and an up-converted emission. The emission properties of various host media activated with Yb$^{3+}$, have been recently studied even in nanoscale form, due to their potential photonic application. Ytterbium (Yb$^{3+}$) doped Y$_2$Si$_2$O$_7$ powders with average particle size 40 were successfully synthesized using the sol-gel technique. At the pressure of 0.01 mbar a wide white light band appeared. The International Commission on Illumination (CIE) coordinates (c) using an illuminance meter for nano-particles at a distance of 5cm. The CIE coordinates were found to be (0.465, 0.377) for white emission under 950 nm excitation.

1This study was financially supported by the Scientific Research Projects Unit (BAPKO) of Marmara University with the Project number FEN-B-150513-0170. One of the authors (Murat Erdem) would like to thank the TUBITAK.

9:18AM D2.00005 Investigations of Er and Yb Doped Y$_2$O$_3$ Nano-powders, GAOZAN DING, Wheaton College, Norton, MA 02766, MURAT ERDEM, Boston College, Chestnut Hill, MA 02467, XUESHENG CHEN, Wheaton College, Norton, MA 02766, BALDASSARE DI BARTOLO, Boston College — The spectral properties of Er$^{3+}$ and Er$^{3+}$ ions have attracted considerable attention and offered the possibility of obtaining an infrared emission and an up-converted emission. The emission properties of various host media activated with Er$^{3+}$, have been recently studied even in nanoscale form, due to their potential photonic application. Erbium (Er$^{3+}$) doped Y$_2$O$_3$ nano-powders, focusing on how the Er and/or Yb concentration affects absorption and infrared to visible upper-conversion luminescence from the materials. Another focus is to study how the infrared excitation power affects red and green upper-conversion luminescence. The absorption spectra are first investigated from 300 nm to 2000 nm for our five samples with various Er and Yb concentrations to determine relevant energy levels and where the strong absorptions are. Their absorption spectra show that all of them have strong absorption around 980 nm. Then the 980nm infrared to the visible-upper-conversion luminescence spectra are measured and studied from 400 to 800 nm. All of our samples of different Er and Yb concentrations show strong red and/or green upper-conversion luminescence, the dependence of which on the infrared laser power is examined. Possible upper-conversion mechanisms are proposed from the results of the luminescence’s power dependence. Our results show that the Er and Yb co-doped Y$_2$O$_3$ nano-powders can be very efficient materials for infrared to visible lighting and other important optical applications. We would like to thank BATE for providing the samples. First author also likes to acknowledge Wheaton’s WRP for the support.

1Undergraduate

Saturday, April 25, 2015 8:30AM - 9:18AM — Session D3 2D Materials

8:30AM D3.00001 Tunable light-matter interaction and the role of hyperbolicity in graphene-hBN system, ANSHUMAN KUMAR, Massachusetts Institute of Technology, TONY LOW, University of Minnesota, KIN HUNG FUNG, Hong Kong Polytechnic University, PHAEDON AVOURIS, IBM T.J. Watson Research Center, NICHOLAS X. FANG, Massachusetts Institute of Technology — Hexagonal boron nitride (hBN) is a natural hyperbolic material which can also accommodate dispersive surface phonon-polariton modes. In this work, we examine theoretically the mid-infrared optical properties of graphene-hBN heterostructures and Er$^{3+}$·Y$_2$O$_3$ nanoparticles with sub-diffraction limit periodicity $\Lambda$. Mechanically exfoliated graphene was deposited onto sinusoidal shape silicon dioxide $\Lambda$=400nm period using a “pick and place” transfer technique. We observed that the graphene is not rigidly clamped, but partially slides to relieve the strain. We model the linewidth variation to extract the local strain variation as well as the sliding in the presence of charge puddling in graphene. Meanwhile, by tuning the surface salinization, the overall strain as well as its variation could also be tuned. This gives us a better understanding on slippage and strain distribution in corrugated graphene.

8:42AM D3.00002 Strain variation in corrugated graphene, XUANYE WANG, KWANCHAN TAN-TIWANICHAPAN, Department of Electrical and Computer Engineering, Boston University, JASON CHRISTOPHER, Department of Physics, Boston University, ROBERTO PAIELLA, ANNA SWAN, Department of Electrical and Computer Engineering, Boston University — Raman spectroscopy is a powerful non-destructive technique for analyzing strain in graphene. Recently there has been interest in making corrugated graphene devices with varying spatial wavelengths $\Lambda$ for plasmonic and THz applications. Transferring graphene onto corrugated substrates introduces strain, which if there was friction would cause a periodic strain variation. However, the strain variation for spatial period $\Lambda$ smaller than the diffraction limit $\lambda$ makes the strain distribution measurement hard. Here we present a detailed study on how strain varies in corrugated graphene with sub-diffraction limit periodicity $\Lambda$. Mechanically exfoliated graphene was deposited onto a SiO$_2$ substrate with $\Lambda$=400nm period using a “pick and place” transfer technique. We observed that the graphene is not rigidly clamped, but partially slides to relieve the strain. We model the linewidth variation to extract the local strain variation as well as the sliding in the presence of charge puddling in graphene. Meanwhile, by tuning the surface salinization, the overall strain as well as its variation could also be tuned. This gives us a better understanding on slippage and strain distribution in corrugated graphene.
8:54AM D3.00003 The Effects of Mica Substrate on Exfoliated Molybdenum Disulfide
- ERIN SUTTON, EDWARD GEORGE, KENNETH BURCH, MARCEL HOEK, Boston College — Molybdenum disulfide is a two-dimensional semiconductor which has recently caught a lot of attention due to its 2D behavior and unique electronic and optical properties, emerging as an analogue to graphene with the advantage of a non-zero band gap. MoS2 consists of atomically thin sheets stacked on top of each other and held together by van der Waals forces, which easily allows for interlayer cleaving. However, as-grown MoS2 usually is strongly doped. We wanted to understand the effects the substrate on which the MoS2 is exfoliated has on the crystal’s properties. We carefully mechanically exfoliated MoS2 on Mica and Hafnium Oxide substrates, and took Raman and photoluminescence measurements of the exfoliated flakes ranging from 1 layer to 5 layer thicknesses. Obtained results contribute to our understanding of substrate-to-crystal interactions, in addition to the crystal lattice and optical properties of two-dimensional atomic crystals.

9:06AM D3.00004 Altering the Optical Properties of Reduced Graphene Oxide by Ozone Treatment
- NICHOLAS LOMBARDO, CALEB MALONEY, KATHARINE HESSE, ANTON NAUMOV, Central Connecticut State University — Due to its remarkable properties, graphene has found multiple applications in optics and electronics. The advancement of graphene-based optoelectronics is dependent on the ability to controllably produce band gaps in graphene. In this work, controlled ozone treatment of reduced graphene oxide (RGO) in water suspensions was employed in order to functionalize it with oxygen-containing groups, yielding graphene oxide (GO). As a result of such processing, a broad fluorescence feature centered at ~ 532 nm was detected from the product, indicating the formation of the optical band gap in previously non-emissive RGO. The fluorescence intensity could be varied by the ozone treatment time, which provides a possibility of controlled modification of graphene oxide optical properties. Theoretical PM3 modeling of functionalized graphene sheets suggests that such fluorescence could arise due to confinement effects or oxygen group-induced defect states in GO.

Saturday, April 25, 2015 10:30AM - 11:30AM —
Session E1 Invited Presentation Saturday NES APS Life Sciences and Engineering Building B01
- Bennett Goldberg, Boston University

10:30AM E1.00001 Two-dimensional materials represent the next frontier in advanced materials for electronic applications. Their extreme thickness (3 or less atoms thick) give them great flexibility, optical transparency and an unsurpassed surface-to-volume ratio. At the same time, TONY HEINZ, Columbia University — Graphene, a single atomic layer of carbon atoms, has attracted great attention worldwide because of its potential for novel science and technology. Recently, this interest has expanded to the much wider class of 2D materials that occur as layers of van-der-Waals crystals. While preserving graphene’s flexibility and tunability by external perturbations, atomically thin layers of this wider set of materials provides access to more varied electronic and optical properties, including semiconducting and insulating behavior. In this presentation, we will discuss some of the distinctive optical properties of this emerging class of atomically thin 2D materials. Graphene has now been investigated across a spectral range from the THz to the UV. The optical properties reveal much interesting physics and show strong tunability in response to means of external gating. Recently, atomically thin layers of semiconductors in the family of transition metal dichalcogenides (MX2 where M = Mo, W and X = S, Se, Te) have also been prepared and investigated. Although weak light emitters in the bulk, at monolayer thickness these materials emit light efficiently. We will describe some of the surprising properties of these systems, from strong and anomalous excitonic effects to valley selective excitation and control.

11:00AM E1.00002 Upper Level Physics MOOCs for Online and Blended Learning
- SAIF RAYYAN, Massachusetts Institute of Technology — I will describe some of the experiments in offering MOOCs (Massive Open Online Courses) for upper level undergraduate and graduate physics courses at the physics department at MIT. As an example, I will discuss 8.05x: Mastering Quantum Mechanics, an online intermediate quantum mechanics course offered openly on the edX platform this Spring (2015). In addition to offering the MOOC, a selected group of MIT students is taking the course for credit, where contact hours are greatly reduced in favor of online activities. I will discuss the process of planning and creating 8.05x, the technologies used, and the differences between the MOOC and the MIT resident offering in terms of demographics, activity and performance. I will also extend the discussion to other past and planned upper level physics MOOCs where the MOOC is used to increase the flexibility of offerings of specialty courses, so students do not have to wait for the next time the course is offered and are able to take the course for credit either via a special offering or via self study.

Saturday, April 25, 2015 11:30AM - 12:06PM —
Session F1 High Energy Physics Life Sciences and Engineering Building B01 - Jason Christopher, Boston University

11:30AM F1.00001 The PHENIX Muon Piston Calorimeter Extension (MPC-EX) at RHIC
- DHHRUV DIXIT, WILLIAM ROH, FERNANDO TORALES-ACOSTA, State Univ of NY- Stony Brook, PHENIX COLLABORATION — The Muon Piston Calorimeter Extension (MPC-EX) is a Silicon(Si) - Tungsten(W) preshower detector that is installed as an extension to the current PHENIX Muon Piston Calorimeter (MPC). The extension consists of eight alternating layers of Si minipad sensors and W absorbers, which allow identification and reconstruction of \( \pi^0 \) mesons out to energies \( > 80 \text{ GeV} \). The MPC-EX will uniquely enable us to measure phenomena related to low momentum partons in the target nucleus and the high momentum partons in the projectile nucleus. Currently, the MPC-EX is taking data in the RHIC Run-15. Run-15 is a p+\( \Lambda \) collision, where \( p \) is a proton and \( \Lambda \) is a heavy ion. The MPC-EX will help distinguish between the direct photons, that result when a valence quark in the projectile scatters off a gluon in the target nucleus, and \( \pi^0 \) decay photons. The measurements at momentum fraction of \( 10^{-2} \) order of magnitude will provide high statistics data that can be used to understand the gluon saturation at low momentum in the nuclei. The test beam data from the Stanford Linear Accelerator Center shows that the MPC-EX causes an EM shower prior to reaching the MPC. The data demonstrates the MPC-EX’s ability to distinguish between double and single EM showers, allowing for \( \pi^0 \) reconstruction.

\(^1\)URECA, LSAMP
11:42AM F1.00002 Spiral Disk Instability in Binary White Dwarf Mergers as a Progenitor to Type Ia Supernovae

11:54AM F1.00003 LHC at CERN – Machine and Experiments

Saturday, April 25, 2015 11:30AM - 12:06PM
Session F2 Biological and Polymer Physics

11:30AM F2.00001 Cell Survivor: Teaching radiobiological intuition with a video game

11:42AM F2.00002 Effect of Chain Stiffness on the Glass Transition Temperature of Polymer Thin Film

11:54AM F2.00003 Mode-locking Behavior of Izhikevich Neurons under Periodic External Forcing

1We are grateful to the support of National Science Foundation (DMR-1310536).