

# American Physical Society New England Section Newsletter

Volume 19, No. 1

Spring 2013

## Co-editors

- Edward Deveney
- Peter K. LeMaire

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**SPRING 2013 APS-NES MEETING**  
**Bridgewater State University, New Sciences and Mathematics**  
**Complex, Bridgewater MA**  
**Friday and Saturday, April 19 & 20, 2013**

## Theme: Biophysics and Optics

The plenary sessions will focus on Biophysics, in particular optical and nano techniques used in cutting-edge biology and chemistry research, as well as Optics; Optics in Industry and in the Advanced labs.

### Invited speakers include:

Ashley Carter (Amherst College)  
Bill Hesse and Steve Wasserman (MIT)  
Nate Derr (Harvard Medical School)  
Sean Ling (Brown University)  
David Weitz (Harvard Univ.)  
Tom Kling (Bridgewater State Univ.)

Authors should submit abstracts through the APS website at <http://abs.aps.org>.

The deadline for abstract submission is **March 29th, 2013**

For registration, travel and lodging information, and an up-to-date conference schedule, and workshop information, please visit the meeting website at <http://www.bridgew.edu/physics/NESAPS/>

For questions please send email to Edward Deveney ([edeveney@bridgew.edu](mailto:edeveney@bridgew.edu))

## BSU Unveils New Science and Mathematics Center Adding to Leadership in STEM Education in Southeastern Massachusetts

The new Center for Science and Mathematics at Bridgewater State University, at \$98.7 million, constitutes the single largest project ever undertaken by an institution in the state university system in Massachusetts.

Fully completed in fall 2012, the 211,300-square-foot facility has more than doubled the amount of teaching and learning space devoted to science and math and features: 35 state-of-the-art teaching labs including 19 specialty labs (for physics, this includes dedicated laser lab, instruments lab, electronics/robotics lab and an academic machine shop); a multi-story glass atrium at the building's core – a public space where students, faculty and members of the community can participate in a shared spirit of discovery; the “World of Science” – an interactive exhibit in which a variety of scientific data can be displayed on a representation of the Earth's surface; a rooftop

observatory with an 18-foot dome and sophisticated astronomical tools along a viewing platform (see article below); a rain garden, greenhouse and botanical garden to encourage active learning and science on display; and a myriad of energy-saving and environmentally friendly elements meeting the high standards of LEED certification.

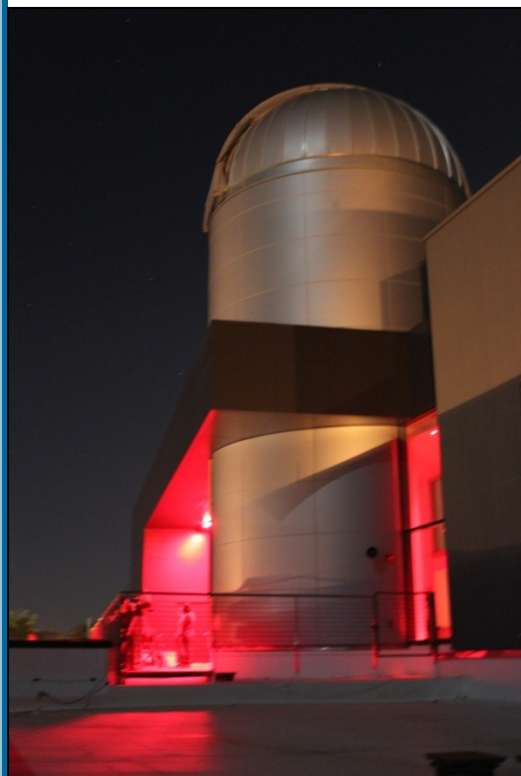
In terms of campus and community impact, the new building provides access for all students to receive STEM skills necessary to succeed in the 21<sup>st</sup> century workforce. Integrate and expand teaching and research facilities, resulting in a cutting-edge undergraduate science, mathematics, and computer science programs for Southeastern Massachusetts; provide outstanding educational opportunities for regional K-12 schools – both students and teachers (outreach and graduate programs) to ensure an adequate supply

of well-prepared and highly effective STEM teachers; and continue to engage numerous economically depressed communities in Southeastern Massachusetts through institutional community outreach programs.



**Authors:**  
Eva Gaffney, John Winters and Ed. Deveney, Bridgewater State University.

### The new BSU Observatory - *Student research, outreach and new programs highlight the excitement of the BSU Physics Program and New Sciences and Mathematics Center*



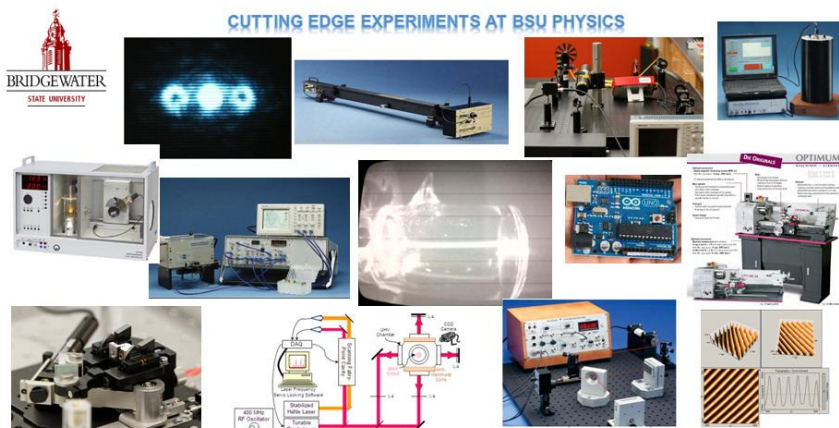
The BSU Observatory includes a fledgling observational research program as well as a growing outreach effort. Our primary instrument – a 14” Celestron Schmidt-Cassegrain mounted on a Paramount ME – became operational in 2012, and is dedicated to student research projects, which so far have included photometry of extrasolar planet candidates and asteroids, as well as astrophotography. The outreach program is dedicated to educating and sparking an interest in science, particularly astronomy, in the regional community by promoting astronomy education, awareness and interest – especially in K-12 students. Events are primarily

student-staffed. Family-oriented activities include public and private viewing events using 8” telescopes as well as hands-on activities for groups of children. These activities include impact cratering, spectroscopy, and scale of the solar system to name a few, and are popular with scout groups. Since the new facility in the Science and Mathematics Center has opened, nearly 3000 guests have participated in the outreach program.

**Author:**  
Jamie Kern, Bridgewater State Univ.

**Kern Observatory, Bridgewater State University**

## BFY labs, 2<sup>nd</sup> –semester of Core Courses and Undergrad Research define BSU Physics Dept.



BSU Physics has always been the place for teachers to get outstanding physics and education backgrounds – a proud tradition that continues to flourish. Just over a decade ago, however, the physics department looked to emphasize a broader program that reflected the desires and needs of both students and Massachusetts STEM interests by adding focus on preparing physics majors for graduate research and local Massachusetts high-tech industries. Today the department boasts that of graduating BSU physics majors roughly a 1/3 go into each of graduate school, industry and high school teaching.

The new look has been achieved by significant additions and emphasis placed in each of the following areas; cutting-edge advanced labs that stretch across all four years of the degree program, 2<sup>nd</sup> semester courses in the core courses, and most significantly the culture of research and one on one mentorship with the

faculty has come to be considered the norm.

Advanced labs (BFY, Beyond First Year Labs) begin with state of the art equipment from the likes of National Instruments, TeachSpin, Thorlabs and more encompassing top-discrete optical, electronics and machining equipment. BFY labs begin with Modern Physics labs in the 1<sup>st</sup> semester 2<sup>nd</sup> year and include experiments such as laser based speed of light, cosmic muon lifetime, single photon double slit, AFM/STM microscopy, X-Ray spectroscopy and even Arduino microprocessor control. Junior year BFY lab courses prepare majors for REUs and on & off campus research opportunities. These include; LabView based Fourier experiments, RLC filters, Rb ground-state hyperfine measurements and pulsed NMR T1, T2 and spin echo experiments. Two additional BFY labs taken between sophomore and senior years are; Modern optics which is based on individual Newport Optics kits (individual discrete optical components, tables and lasers) and Digital Electronics Course which covers analog, digital through microprocessors

using National Instruments ELVIS desktop power, measurement and prototyping supplies, MultiSim electronic simulations and LabView programming.

All of these new BFY labs are housed in BSU's new Science and Mathematics Complex (see article on previous page) in dedicated Atomic/Molecular and Optics Laser, Instruments, and Electronics/Robotics Labs plus an academic machine shop was developed to support the experimentation and research.

As with the lab experience, course options the department now offer reflect the desire for our students to not only be prepared for but ready to contribute immediately at the graduate level. These include; 2<sup>nd</sup> semesters of mechanics, electrodynamics and quantum mechanics. Additionally Quantum III (particles), astrophysics, computational physics and even General Relativity give BSU majors head start and more for impact at the graduate level.

Undergraduate research has become the norm and often the center piece of the physics degree at BSU. Astrophysics using the new BSU telescope facility, General Relativity theory (gravitational lensing), and the experimental/theory Atomic/Molecular/Optical programs have all had tremendous impact on nearly all of BSU physics majors. BSU undergrad research has been a solid jumping board for students moving on successfully into graduate physics programs as well as for those entering the workforce, particularly in local optics and recently bio-optics fields.

**Author, Ed Deveney**

## Transition from College to University

Founded in 1840 by Horace Mann, Bridgewater State University was home to the oldest permanently sited teacher preparation program. The institution was one of the most prolific generators of new teachers by training more science and math teachers than any institution in Massachu-

setts. Bridgewater State University has grown in the number of innovative academic programs to help ensure that students are prepared to think critically, communicate effectively, and act responsibly within a context of personal and professional ethics.

The official renaming ceremony

that took place on September 1, 2010 marks the sixth name change since its founding. Legislation enacted on July 28, 2010 created the Massachusetts state university system. The bill recognizes that the Massachusetts state colleges already were regional teaching universities in everything but name. As comprehensive institutions offering undergraduate and graduate degrees in a wide range of disciplines, the state colleges all met nationally recognized criteria of being universities. The state university system more accurately describes the breadth and depth of the educational offerings at Bridgewater State University. Bridgewater State University is the home of five schools and academic departments which offer its 11,000 students more than 90 undergraduate and graduate degree programs.

## BSU STREAMS Grant : Increasing numbers of STEM graduates



**Above Left:** Colin Gregory, "PAL" in a STREAMS class

**STudent Retention Enhancement Across Mathematics & Science**, or STREAMS, is a 5 year, \$1 million NSF STEP grant (DUE-0969109) designed to increase the number of science and math majors graduating from Bridgewater State University by about 40 graduates per year by the end of grant in 2015. The grant supports student retention in all six STEM departments in the Bartlett College of Science and Mathematics through student support and changes in pedagogy aimed to increase the amount of inquiry-based, small group learning in introductory classes and throughout the curriculum. The grant team includes Dr.

Thomas Kling and Dr. Jeff Williams of the physics department, Dr. Jennifer Mendell in biology, Dr. Stephen Waratuke in chemistry, and Dr. Matthew Salomone in mathematics.

In physics, Drs. Kling and Williams have used grant funds to redesign the introductory physics sequence from a typical lecture & lab structure to a mixed lecture & lab format that emphasizes student inquiry, student experimental design, and small group work. Building on existing studio physics and discovery physics

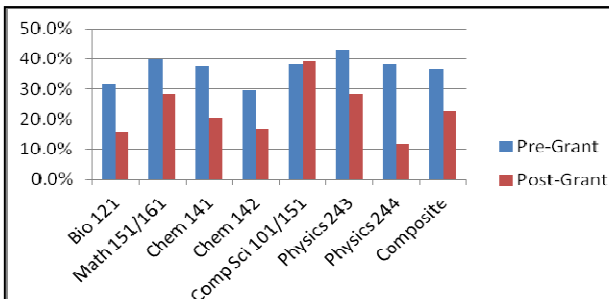
models of instruction, Bridgewater is developing its own Process Oriented Guided Inquiry Learning (or POGIL) style course materials that in many cases replace lecture with information students read and work through in small groups, followed by a combination of problems or mini-experiments. Class sizes run in the low twenties, and the students are supported by a course instructor and a senior physics undergraduate Peer Assistant for Learning, or PAL.

The results of these changes have been a significant reduction in the percentage of D, F, and W grades in physics. In the two years prior to the grant, calculus based physics courses saw a rate 43% DFW in General Physics I and 38% in General Physics II, in the one and a half years after the changes began implementation, those rates have fallen to 28% and 12% respectively.

Similar results have been achieved in introductory biology, chemistry, pre-calculus and calculus at Bridgewater, all of which have significantly lowered their DFW rates. In part due to the efforts of STREAMS, enrollment in the College of Science and Mathematics has increased from 916 to 1209 students enrolled in biology, chemistry, computer science, mathematics and physics from fall 2010 to fall 2012. Physics has seen particularly strong growth, having increased from 33 to 60 majors over this period.

### Author

Thomas Kling, (below right, in a STREAMS class)  
Bridgewater State University



Percentage of students receive D, F, or W grades before grant activities and after grant activities. The composite is the headcount weighted average of all the courses supported.



## Modern Physics and Dependable Course Schedule Highlight Bridgewater State University MAT Program



*The curriculum is designed to cater to individualized levels of ability and assessment.*

In conjunction with the opening of the new \$100 million science complex at Bridgewater State University, the Department of Physics is proud to unveil a revised Master of Arts in Teaching (MAT) in physics program. This professional licensure degree fosters growth in physics, while also enhancing modern teaching techniques. As the only such program offered at a public institution in eastern Massachusetts, this

program meets the needs of local physics teachers and enthusiasts.

Dr. Edward Deveney, graduate program coordinator and professor of physics, said the goal of the new MAT in physics curriculum is both to, "... emphasize a rigorous study of modern physics (theory, experiment and research) and to provide teachers with a convenient and dependable course schedule."

Courses offered during the fall and spring semesters will meet once per week in the evening while courses offered during the summer will be held in a one-week intensive format. Also noteworthy, graduate physics classes do not require prerequisites – allowing students to choose their own course sequence. This offers students a dependable schedule to plan for and complete within two years. These courses can be used not only for teachers in the MAT in physics program, but also for professional development purposes, earning PDPs for teachers.

The curriculum is designed to cater to individualized levels of ability and assessment.

While students with a less extensive background in physics will find that courses emphasize new foundations and/or refinement of previous skills, recent undergraduates with a stronger physics background will explore more challenging content. There is also an opportunity for students to design and complete a thesis firmly establishing a close working connection with BSU physics faculty members.

Students will experience hands-on learning with state-of-the-art equipment used in modern physics, optics and astrophysics. Access to the new observatory is also available for teachers looking for research tools in the field of astronomy. Interested students and teachers are encouraged to schedule a tour of the new facilities.

Contact Prof Edward Deveney [edeveney@bridgew.edu](mailto:edeveney@bridgew.edu) or the Department of Physics at [www.bridgew.edu/physics/](http://www.bridgew.edu/physics/) to schedule your visit today.

### Authors

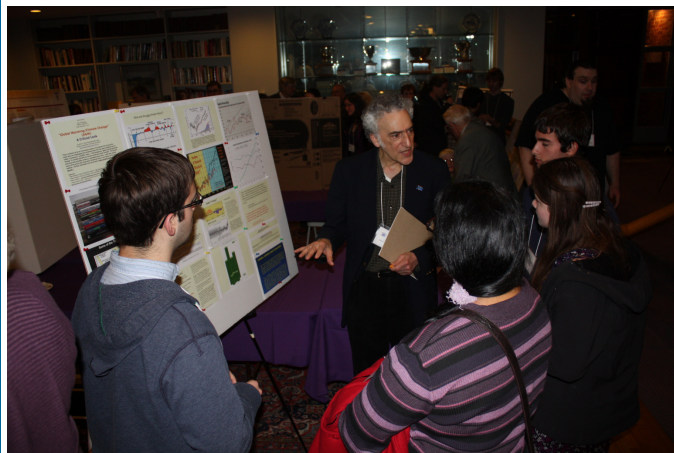
Dr. Edward Deveney, Professor of Physics and Ethan Bernstein, Associate Director of Marketing and Recruitment

**Do you have interesting Physics related articles, new programs, research report, physics talking points etc. that you will like to share with the New England Physics Community?**

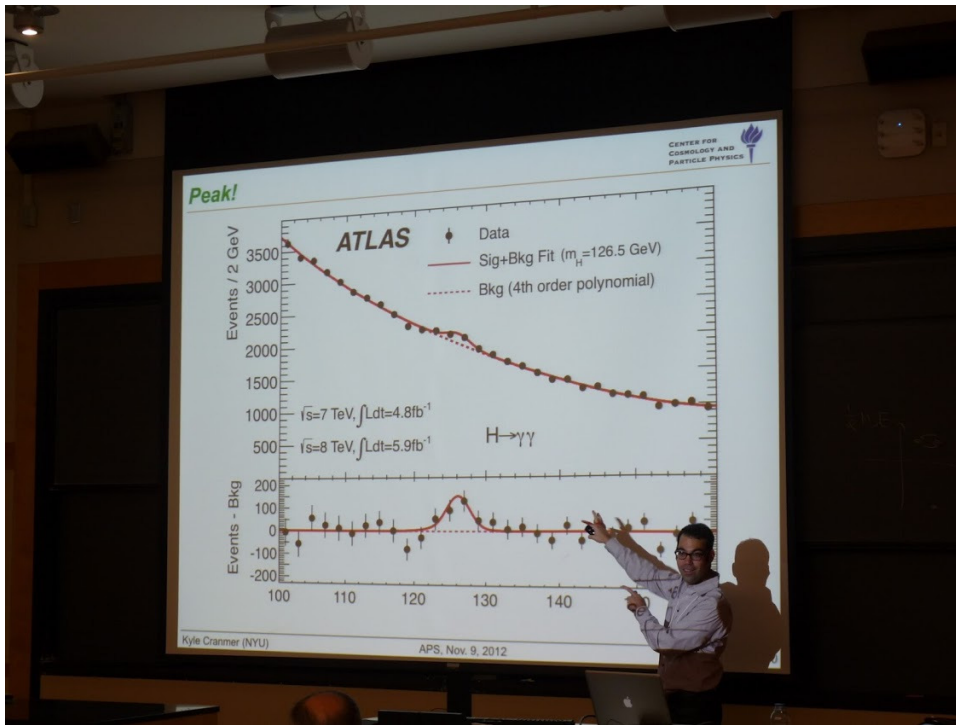
**Send them to the co-editors:**

**Ed Deveney ([edeveney@bridgew.edu](mailto:edeveney@bridgew.edu)), Peter LeMaire ([lemaire@ccsu.edu](mailto:lemaire@ccsu.edu))**

## Fall 2012 NES AAPT/NES APS Joint Meeting Scene, Williams College, MA.

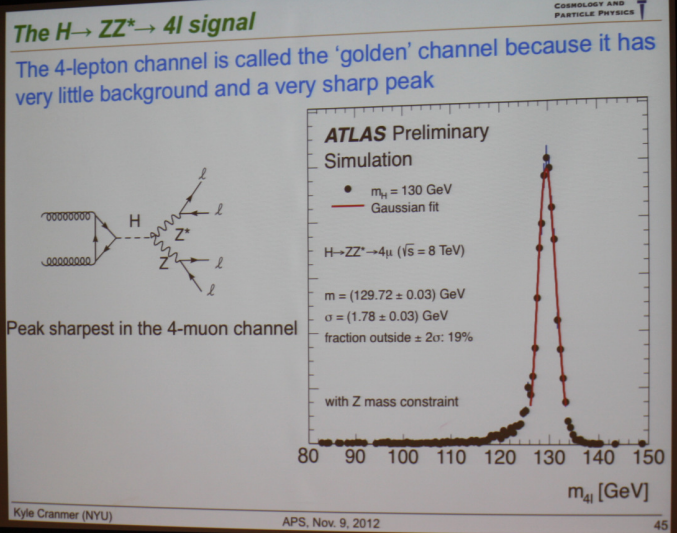
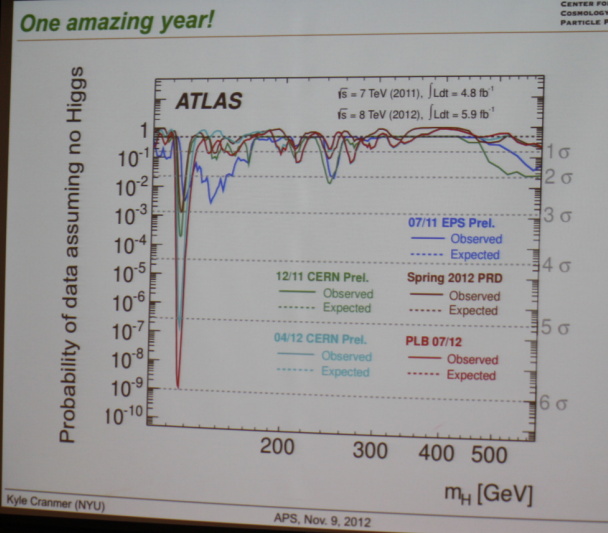


Fall 2012 NES AAPT/NES Joint Meeting Selected Talks and Abstracts



**Discovery!**  
**How we did it**  
**and what we**  
**know so far ,**  
**KYLE CRANMER,**  
**New York University**

Photo courtesy of Paul Carr, Past Co-editor of APS-NES Newsletter



One of the great intellectual achievements of human kind is the standard model of particle physics. This theory describes how fundamental particles like electrons and quarks interact and gives us the building blocks for understanding the universe we see around us today.

A key part of this theory is the Higgs field, which permeates space and time. Finding the Higgs boson - the experimental manifestation of this field - and measuring its properties has

become one of the most fundamental scientific endeavors in history. After decades of searching, it was announced by CERN on July 4, 2012 that the large international collaborations ATLAS and CMS have discovered a new particle in their search for the Higgs boson using the Large Hadron Collider.

## Fall 2012 NES AAPT/NES APS Joint Meeting Selected Talks and Abstracts

### Subwavelength manipulation of light



**Author:**  
MICHAEL NAUGHTON, Boston College, giving Invited Talk.

We discuss a novel nanoscale platform offering utility in nanophotonics, photovoltaics, visual prosthetics, and biological and chemical sensing. As subwavelength optical waveguides, these nanostructures can be used in a range of nanoscale manipulations of light, including optical nanomicroscopy and lithography, high efficiency solar cells, high electrode-density retinal implants and discrete optical metamaterials. A modification of the basic structure enables the fabrication of highly sensitive “nanocavity” biochemical sensors and nanoscale bipolar neurostimulators. We will

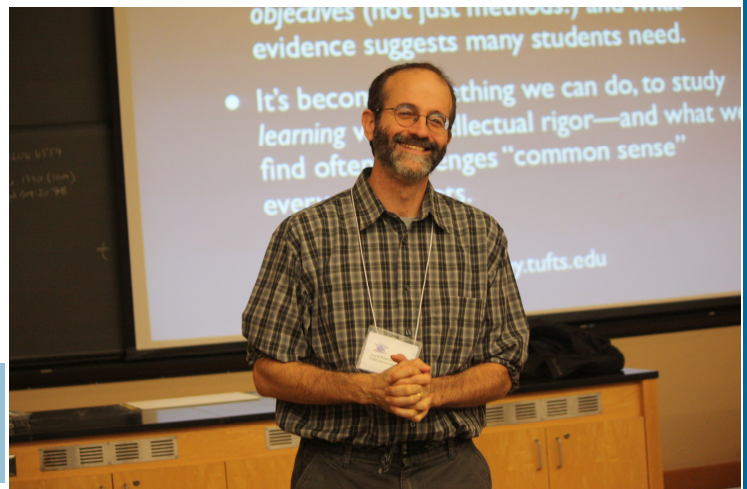
report on aspects of these applications, with emphasis on radial junction “nanocoax” thin film solar cells. This structure allows for a unique decoupling of the optical and electronic length scales in photovoltaic devices, enabling highly efficient charge extraction in ultrathin films with, paradoxically, highly efficient light collection. The nanocoax thus exhibits strong optical absorption across the visible, and state-of-the-art power conversion efficiency using photovoltaics thinner than carrier (electron and hole) diffusion lengths, suggesting a new path to high efficiency solar power.

### What do the students need?

The instruction we offer students, at any level, presumably reflects what we believe will help them understand physics. But we don’t often subject our beliefs to scrutiny. Most physics instructors work from common sense assumptions about what students need clear explanations, demonstrations, motivation and practice. As in physics, however, common sense ideas (e.g. “objects move because they are pushed”) aren’t always correct. I will present evidence that these usual assumptions are insufficient and offer an expanded set of possibilities, focus-

ing in particular on how students understand knowledge and learning. In some cases what students most need is help taking a different approach to learning, a “refinement of everyday thinking” (Einstein, 1936) rather than a reception of information.

**Author:**  
DAVID HAMMER, (right)  
Tufts University giving  
Invited Talk



### Dynamics of Dust Aggregates in a Complex Plasma



ALLEN DAVIS, presenting his paper at the Fall 2012 APS-NES meeting.

Charged dust aggregates play an important role in many astrophysical phenomena, such as early stages of protostellar and protoplanetary growth, the dynamics of planetary rings and cometary tails, and the formation of noctilucent clouds in earth’s upper atmosphere. Dust is also expected to be an unwanted byproduct in the operation of plasma fusion devices, such as ITER. In all of these environments, direct study of the dust aggregates in their in situ environment is extremely difficult, if not impossible. As a model for these complex plasma environments, dust aggregates are formed in a laboratory plasma as monodisperse spheres are accelerated in a self-excited dust density wave. Indi-

vidual dust aggregates are perturbed using a diode pumped solid state laser (Coherent VERDI) with their motions recorded by a high-speed camera at 1000 fps. Analysis of the particle motion allows determination of the aggregate characteristics which determine the grain dynamics, such as charge, mass, and gas drag.

**Authors**  
ALLEN DAVIS, Williams College,  
JORGE CARMONA-REYES, LORIN  
MATTHEWS, TRUELL HYDE, Baylor  
University



## Want to demystify Physics? Call Ehrenfest!



**Dmitry V. Zhdanov,**  
Northwestern Univ.

Presenting his paper  
entitled “Ehrenfest  
This”  
at the Fall 2012  
APS-NES meeting

Modern theoretical physics is remarkably successful in explaining a broad variety of phenomena. This ever enlarging body of knowledge can give the perception that physics is a complex network of theories and models. However, the title of Schwinger’s book [1] paraphrased as “Any physical theory is a symbolic representation of the experimental evidence supporting it” provided motivation to formulate a new broadly applicable design principle for physics.

The application of this principle leads to a theory-generating ‘machine’, which returns a physical theory not only describing experimental data supplied as input (see Fig. 1), but also making verifiable predictions. This machine concept, with roots going back to Ehrenfest, allows for a deeper understanding the connections between different branches of physics — from classical mechanics to quantum field theory — and may also provide an effective tool for creating new theories [2].

The automated Ehrenfest theory-generating machine requires a standardized symbolic language for representing

cal observable  $X$  is associated with a self-adjoint operator  $\hat{X}$  acting on this space, such that the corresponding mean value is given by

$$\langle X \rangle = \langle \Psi | \hat{X} | \Psi \rangle \quad (1)$$

These axioms are consistent with experimental data accessible in the form of averages

$\langle X_i(t) \rangle$ . If adequate measurements are available, then the collected data can be used to construct the averages’ evolution laws in the form:

$$\frac{d}{dt} \langle X_i \rangle = f(\langle X_1 \rangle, \langle X_2 \rangle, \dots, \langle X_i \rangle, \dots)$$

where  $f_i$  are system-specific real-valued functions. The experimental knowledge may be translated into the Hilbert space framework through equation (1) resulting in a set of equations resembling the celebrated Ehrenfest theorems of quantum mechanics [3]. These equations form the basis for a theory-generating machine, which deduces the state

space, algebra of the operators

$\hat{X}_i$ , equations of motion, etc.

For example, consider the simplest case of a particle with coordinate  $x$ , momentum  $p$  and mass  $m$  moving in potential  $U$  expressed in the Ehrenfest formulation

$$\begin{aligned} \frac{d}{dt} \langle \Psi | \hat{x} | \Psi \rangle &= \frac{1}{m} \langle \Psi | \hat{p} | \Psi \rangle \\ \frac{d}{dt} \langle \Psi | \hat{p} | \Psi \rangle &= - \langle \Psi | U'(\hat{x}) | \Psi \rangle \end{aligned}$$

As these equations are valid for any state  $|\Psi\rangle$ , they can be solved in terms of a

generator  $\hat{G}$  for the motion such that

$$i \frac{\partial}{\partial t} |\Psi\rangle = \hat{G} |\Psi\rangle$$

The form of  $\hat{G}$  crucially depends on whether  $x$  and  $p$  are simultaneously measurable [2]. One recovers the classical Liouville equation if both  $x$  and  $p$  can be measured at the same time; otherwise, the Schrödinger equation is deduced. This is a particular manifestation of the differences between classical and quantum mechanics reducing to evaluation of the com-

mutator  $[\hat{x}, \hat{p}]$ .

The theory-generating machine depicted in Fig. 1 has already led to systematic and transparent Ehrenfest-based physics with novel results [4]. Ehrenfest-like theorems are sufficient to construct fundamental equations of nonrelativistic and relativistic, classical and quantum physics [2]. Additionally, the Ehrenfest theory-generating machine provides a conceptual framework to address many open problems in relativistic transport theory, hybrid system modeling, and rotational dynamics. An ultimate goal is the translation of the Ehrenfest machine into practical ‘hardware’ for experimental data analysis aiming towards the discovery of new theoretical insights. Research in these directions is in progress.

[1] J. Schwinger (2001) *Quantum mechanics: symbolism of atomic measurements*. Springer.

[2] D. I. Bondar, R. Cabrera, R. R. Lompay, M. Yu. Ivanov, H. A. Rabitz, Phys. Rev. Lett. **109**, 190403 (2012); R. Cabrera, D. I. Bondar, and H. A. Rabitz, arXiv:1107.5139.

[3] P. Ehrenfest, Zeitschrift für Physik A Ausgabe **45**(7-8), 455-457 (1927).

[4] D. I. Bondar, R. Cabrera, D. V. Zhdanov, and H. A. Rabitz,



Fig. 1: Design principle in action

experiments. This universal format is specified by the following postulates: i) The states of a physical system are represented by normalized vectors  $|\Psi\rangle$  of a complex Hilbert space, ii) each physi-

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## Menagerie of viruses and physical principles of their organization



MURUGAPPAN  
MUTHUKUMAR,  
*University of Massachusetts*  
*Giving Invited Talk at the*  
*meeting*

Viruses proliferate around us. Speaking of only the bacteriophage in world's oceans, they can measure more than 200 million light years if arranged head to tail. In addition to the bacteriophages, there are myriads of other viruses. The simplest generic morphology of viruses is that they are made of either icosahedral or cylindrical shell (capsid) made of proteins. The capsid encloses the genome, which is constituted by one or a few ribonucleic acid chains or deoxyribonucleic acid chains.

We have investigated the organization of genomes inside the capsids in a variety of viruses and explored the possibility of a major underlying mechanism for virus assembly. Guided by experimental facts on the spontaneity of virus assembly, we have addressed the conformational entropy of the capsid proteins and the polynucleotides, by using field theoretic and statistical mechanics tools in combination with computer simulations. We show that the virus assembly in all single stranded viruses follows a simple rule of charge balance between the proteins and the genome, without any regard to sequences. This result is in contrast to the long-held view that specific interactions among particular sequences

of amino acid residues and nucleotides control the genome packing. Our results are able to predict the essential aspects of genome packing in diversely different viruses, such as the genome size and its density distribution. All single stranded viruses evolved over billions of years follow this rule of charge balance: the amount of (negatively charged) genetic material packaged inside a virus is simply dictated by the amount of (positively charged) capsid proteins available for holding the genome.

Although the amount of packaged genome inside the single stranded RNA viruses is ruled by charge balance and not specific sequences, the kinetics of assembly is controlled by sequences. The computer simulations show that the assembly kinetics follows the classical nucleation and growth mechanism, and that the familiar concepts of kinetics of first order phase transitions used in physics apply for virus assembly as well.

Our work has opened up technological strategies for artificially encapsidating and subsequently delivering genes to desired targets.

We have also investigated the transloca-

tion of DNA/RNA through protein nanopores. The translocation of electrically charged macromolecules through narrow channels is a fundamental process in life. When a polymer is forced to translocate through a narrow path, its conformational entropy is reduced, resulting in a free energy barrier. This free energy barrier is additionally modulated by potential interactions between the polymer and the pore. The biophysics of polymer translocation process requires an adequate description of polyelectrolyte dynamics, electrolyte dynamics, and hydrodynamics, and the confinement effects from the charge-decorated pores. The experimental data on model nanopores and simplifying in vitro conditions are already bewildering with many puzzles. By a combination of statistical mechanics theory and computer simulations, we have derived a unifying theory and organized diverse set of phenomenological observations into a few key principles. While our results are useful in explaining the present in vitro experiments with implications to DNA-sequencing in biotechnology, they open up an opportunity to help to understand the much more complicated in vivo translocation processes by using polymer physics concepts.

## From the editors: New Look and Ideas for the NESAPS Newsletter

Welcome to the NESAPS Spring 2013 Newsletter.

You may have taken note of changes already, most notably the inevitable on line version, but the editors would also like to draw attention to a general theme for the newsletter being tried out thanks to the ease of online publication.

Newsletters will now give significant play to previous and upcoming NESAPS and AAPT

meetings. Articles will highlight the previous meeting and then will give full attention to the upcoming meeting in particular introducing readers to the host institution and meeting program. In this 1st issue, this was easy for one of the co-editors! Additionally, editors have put in a new section to spark even more interest and discussion. This section will feature discussion and articles on various

physics related topics. We are seeking a catchy name for this section. Remaining parts of the Newsletter cover all the remaining news and material that past issues covered including contributed local news and letters to the editor.

We are open of course to all comments and suggestions and hope to make the online Newsletter a great reading experience and highly interactive.

## Spring Meeting of New England Section of AAPT April 12/13 2013

at [Milton Academy](#)

### Strengthening the Pedagogy of Physics Teaching

<http://aapt-nes.org/spring-2013-meeting/>

[Agenda](#)

**Friday Night:**

**Keynote Speaker: Ronald Thorton**

**Demo Sharathon**

**Contributed Poster Presentations**

**Saturday:**

**Contributed Oral Presentations**

**Invited Speakers: Jerry Touger and Alex Griswold**

**Panel Discussion on Minute Physics and What we should be teaching**

**Remote Address from AAPT HQ**

**Demo Show**

**Workshops**

**Call for Presenters:** [Submit an abstract](#) for a **poster** (Friday Night) OR **oral presentation** (Saturday Morning). We are looking for both poster presentations and oral presentations. Deadline March 9th.

We accept all papers related to the teaching of physics, but are particularly interested in submissions for the following strands:

1. Transitioning to the Teaching of Physics from other Careers
2. Physics Education Research
3. Methodology and Curriculum in Pre-service Teaching Programs

Workshops include: Modeling, Collaboration Software, and Photoelectric Make n Take.

[Registration information available online:](#)

Registration Fee: \$40

Friday Night Banquet Fee: \$40

## BioPhysics — A Must New Trend

Physics has always played ubiquitous, critical and indispensable roles in the understanding of our world and the development of technological applications to enhance the human condition. The study and application of physics continues to be even more critical as ability of science to study smaller and smaller things that has spawned the very active research and application in the area of nanoscience and nanotechnology (NSNT), continues to grow unabated. The quest for smaller and more efficient devices and machinery took a giant leap when, in 1947, physicist and Nobel laureate John Bardeen and his colleagues discovered the transistor leading to integrated circuits that in turn have led to the development and application of high powered, high speed micro to large scale computers in communications, analytical and imaging systems. In his 1959 now popular speech “There’s plenty of room at the bottom”<sup>1</sup>, Physicist Richard Feynman mused about the sort of studies that are now the focus of NSNT. Significant strides and renewed interest in “things at the bottom” came with the discovery and invention of instrumentation to study matter at the nano level such as the Scanning Tunneling Microscope (STM) in 1982, and the Atomic Force Microscope (AFM) in 1989. Inextricably linked with the study of micro and nano level science, are the laws of physics. As we move into the nano regime, quantum physics and its application become indispensable. For example as we go from macro sized materials to nano materials, “inert materials become catalysts (platinum), stable materials turn combustible (aluminum), solids turn into liquid at room temperature (gold), insulators become conductors (silicon)”<sup>2</sup>. Closely linked to miniaturization of devices, among a host of others, is the physics and study of electron transport and magnetic properties of materials needed for “mesoscopic and nano scale devices”<sup>3</sup>.



Brilliant iridescent colors of butterflies and feathers of a number of birds are as a result of interference of light by intricately arranged photonic structures.

The colors of flowers on the other hand are pigments.

*Photo courtesy of Sophia LeMaire, Brigham and Women's Hospital, Boston MA.*

If there is one area in the sciences that is ripe with the study and application of NSNT more than any other, it is the Biological Sciences and applications in Medicine. Unfortunately, traditionally, the study of Biology has been seen, due in part to the extreme complexity of biological systems, as simply a descriptive science leading to trepidation on the part of physics

programs to encourage their students in this all important area of science. Over the years, there have been calls by a number of notable scientists for more active involvement of physicists in the study and application of biological systems. At the 1999 Centennial March Meeting of the American Physical Society in Atlanta, Dr. Harold Varmus, the then Director of the National Institute of Health, and currently the Director of the National Cancer Institute, gave a plenary talk on “The impact of Physics on Biology and Medicine” in which he exhorted the physics community to become more active in the study of biological systems and stressed the historical use and current need for the skill set developed in the study of physics to be brought to bear on the large variety of pertinent and interesting questions in Biology and medicine, from device and instrumentation development to fundamental understanding and application of biological systems. More recently at the Fall 2010 meeting of the APS-NES at

Brown University, physicist and Nobel laureate Leon Cooper, who now devotes most of his time to biological studies, stressed the importance of more physics involvement in biological systems to help solve some of the world’s most difficult problems, and also to spur innovation.

There has been significant progress in this endeavor with a number of physics pro-

grams offering Biophysics degrees. However more can be done for students in undergraduate physics programs to be exposed to application of basic physics in these areas, because a good number of the topics needed to tackle biological problems are already being taught in undergraduate programs.

For example basic physics concepts of elasticity, Young’s modulus, effect of added mass on the natural frequency of vibrating systems are used in the design and applications of micromechanical

cantilever used as an ultrasensitive pH microsensors<sup>4</sup>, for NSNT applications in biochemical or biological processes, in PSA (Prostate Specific Antigen) in cancer detection<sup>5</sup>, as a mass sensor in the detection of viruses<sup>6</sup>, and in the study of “DNA hybridization and receptor-ligand binding”<sup>7</sup> to name a few. Another basic topic in undergraduate programs - harmonic oscillators, energy in oscillators and mechanical resonators, are applied in bacteria and virus mass detection using microresonators<sup>8,9</sup>. Even the data acquisition and analysis in these areas are already available to physics undergraduates. For example, data acquisition and analysis in the use of the microcantilever sensors, require the use strain gages, accelerometers, lasers coupled with Position Sensitive Detectors (PSD) and standard computer controlled data acquisition and analysis systems such as Fast Fourier Transform (FFT) programs.

Research and engineering of sensors needed for understanding and application of NSNT has been ongoing for decades,

with significant developments<sup>10</sup>. The engineering of sensors and other nano devices are, by and large, based on “positional assembly” but with interesting advances into “self assembly”. The energy required to power nano devices also present interesting challenges. One interesting development has been the work of Soong et al, in the development of “a hybrid nanomechanical device powered by a biomolecular motor”<sup>11</sup>. The source of such energy is ATP (Adenosine Triphosphate). NSNT requires the use of both classical as well as modern and quantum physics. For example, in nano devices, actuation has been done using Lorentz forces, AC Electric fields, differential thermal expansion of bilayers etc., and response detected, observed and measured using a variety of basic physics including electromagnetic induction, electron tunneling, and laser techniques<sup>10</sup>. Quantum Physics is especially indispensable as we venture into systems at the molecular and atomic levels. The quantum physics topics such as one dimensional step potentials, potential wells and barriers leading to tunneling, is important in understanding “Charge transport through DNA” and thus the study, design and application of bioelectronics<sup>12</sup>. Electron tunneling is also used to sensitively detect sub-nanometer motion<sup>10</sup>.

Optical techniques play a significant

role in nanofabrication, understanding the science of NSNT and response detection in nanosystems. For example in “a mesh structure that forms an oscillating mirror as part of a Fabry-Perot device”, the motion is detected by monitoring optical interference changes as the mirror moves<sup>10</sup>. Ellipsometry, a technique that allows in-situ property and thickness measurements and is sensitive to even atomic layering, is based on wave optics.

Then there is also the growing area of Biomimetics<sup>13,14,15</sup>, where Physicists and Engineers take cues from nature in the design of new materials and devices.

In addition to an infinite number of opportunities for research and application that the study of biological systems provides to physicists, it also provides stronger basis for medical school and opens up a wide range of jobs and advancement opportunities in biotechnology, and NSNT for graduates of physics programs. It is imperative that Physics (and Engineering) departments aggressively work toward providing training in Biology to tackle the current and next generation of scientific problems.

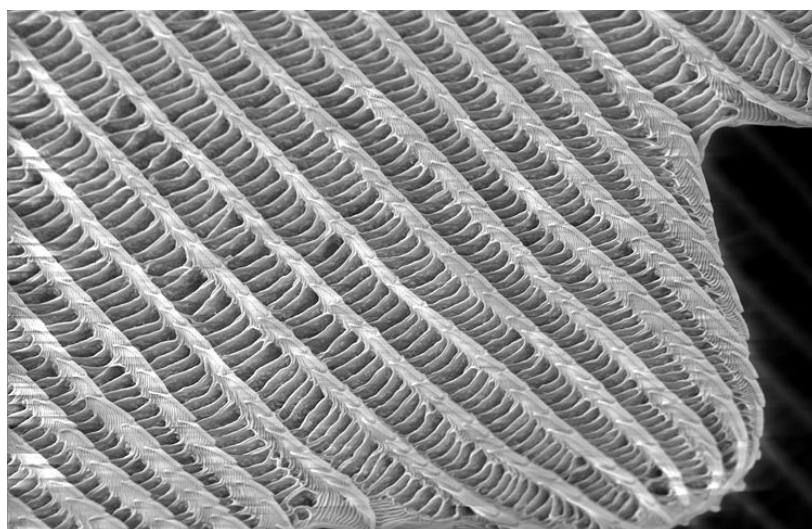
It is thus suggested that Physics undergraduate programs that may not be able to set up a full fledged Biophysics program, could, in collaboration with their Biology departments, set up “Concentration” or “Certificate” programs using selected existing courses in

Biology/Biomolecular Sciences to provide opportunities for their physics majors who will like to venture into these areas, and to consider these areas as viable options for further studies.

The Theme of the Spring 2013 APS-NES meeting on “Biophysics and Optics”, is thus very timely and urgent.

## References.

1. R. Feynman, “There’s Plenty of Room at the Bottom”, *J. Micromechanical Systems*, **1**, 1, (1992) 60.
2. [www.nanowerk.com](http://www.nanowerk.com)
3. H. G. Craighead, “Nanoelectromechanical systems”, *Science*, **290**, (2000) 1532
4. R. Bashir, J. Z. Hilt, O. Elibol, A. Gupta, N. A. Peppas, “Micromechanical cantilever as an ultrasensitive pH microsensor”, *Appl. Phys. Lett.*, **81**, 16, (2002) 3091.
5. Guanghua Wu, Ram H. Datar, Karolyn M. Hansen, Thomas Thundat, Richard J. Cote & Arun Majumdar, “*Nature Biotechnology*”, **19**, (1 September 2001) 856.
6. B. Ilic, Y. Yang, and H. G. Craighead, “Virus detection using nanoelectromechanical devices”, *Appl. Phys. Lett.*, **85**, 13, (2004) 2604.
7. J. Fritz, M. K. Baller, H. P. Lang, H. Rothulzen, P. Vettiger, E. Meyer, H.-J. Guntherodt, C. H. Gerber, J. K. Gimzewski, “Translating Biomolecular Recognition into Nanomechanics”, *Science*, **288**, (2000) 316.
8. B. Ilic, D. Czaplowski, and H. G. Craighead, “Mechanical resonant immunospecific biological detector”, *Appl. Phys. Lett.*, **77**, 3, (2000) 450.
9. A. Gupta, D. Akin, and R. Bashir, “Single virus particle mass detection using microresonators with nanoscale thickness”, *Appl. Phys. Lett.*, **84**, 11, (2004) 1976.
10. H. G. Craighead, “Nanoelectromechanical systems”, *Science*, **290**, (2000) 1532.
11. R.K. Soong, G. D. Bachand, H. P. Neves, A. G. Olkhovets, H. G. Craighead, and C. D. Montemagno, “Powering an Inorganic Nanodevice with Biomolecular Motor”, *Science*, **290**, (2000) 1555.
12. I. Willner and E. Katz, in *Bioelectronics – An Introduction*, Wiley-VCH Verlag GmbH & Co (pub) (2005).
13. Bharat Bhushan, “Biomimetics: lessons from nature – an overview” *Phil. Trans. R. Soc. A* (2009) 367, **1445–1486**.
14. Julian F. V. Vincent, Olga A. Bogatyreva, Nikolaj R. Bogatyrev, Adrian Bowyer and Anja-Karina Pahl, “Biomimetics: its practice and theory”, *J. R. Soc. Interface* (2006) **3**, 471–482.
15. Jeremy W. Galusha, Lauren R. Richey, Matthew R. Jorgensen, John S. Gardner and Michael H. Bartl, *J. Mater. Chem.*, **2010**, **20**, 1277-1284



SEM Image peacock wing showing photonic structures

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x5000

5 μm

5kV

19mm

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## APS-NES



Past Co-editors, Paul Carr (left) and Laurence ("Larry") Gould (right) at an APS-NES meeting

## Parting Comments of Past co-editors (2005 –2012)

Since our first APS NES Newsletter in the spring of 2005, we have added photographs of all our meetings. We have also added a number of editorials on energy management and climate change. For example, in the Spring 2010 issue, I published the editorial "Copenhagen 1600, 2009, and 1941." This dealt with Shakespeare's tragedy "Hamlet," the UN Climate conference held in Copenhagen, and Heisenberg's visit to Neil's Bohr. Our editorials stimulated a number of Letters to the Editor agreeing or disagreeing with us. Climate change will be of increasing importance in the future.

Wishing you the best,

...**Paul Carr**

It has been very challenging to serve as Co-Editor (with Paul Carr). That challenge included being partly responsible for determining the format, layout, and contributions to the Newsletter as well as getting the publication distributed in a timely manner.

Since the Fall 2007 issue (where I set out my first extensive editorial) and continuing in every issue through the Fall 2012, I and others have spent a lot of time explaining the nature of the significant and serious problems in both the methodology and claims that there is dangerous human-caused climate change (AGW). I refer those interested to the links at [http://www.aps.org/units/](http://www.aps.org/units/nes/newsletters/)

[nes/newsletters/](http://www.aps.org/units/nes/newsletters/) My only regret is — given that we would publish, *verbatim*, Letters to the Editor — there were so few letters; on AGW as well as on any other topic.

I would like to thank Paul Carr for his contributions (including most of the pictures) to the Newsletter. And I would also like to thank the (APS-imposed) Editorial Board for letting the reign of a free press take place, particularly on the AGW issue.

It has been a privilege for me to have been Co-Editor of the NES APS Newsletter. And I wish you, as the new Co-Editors, all the best as you go into the Spring 2013 issue.

...**Larry Gould**

*Contributions to this newsletter have not been peer-refereed. They represent solely the view (s) of the author (s) and not necessarily the views of APS.*