The Industrial Physics Forum 2007: The Energy Challenge

Room: 602/603 - Session IPF-TuA

Frontiers in Physics

Moderator: J. Hobbs, American Institute of Physics

2:00pm **IPF-TuA2 Probing the Intrinsic Magnetism of the Electron (and Measuring the Fine Structure Constant)**, ***G. Gabrielse***, Harvard University **INVITED**

A single electron is suspended by itself for months at a time. The electron and apparatus together form an artificial, home-made atom whose energy levels we probe using quantum jump spectroscopy. Much as measurements of the magnetism of the earth reveal something about the inner structure of the earth, measurements of the electron's intrinsic magnetism tells about the inner structure of the simplest of elementary particles. For the first time since 1987 the electron's magnetic moment is measured with a higher accuracy. The new measurement, together with quantum electrodynamics theory, determines the important fine structure constant about ten times more precisely than does any rival method. Many interesting techniques are employed, including the inhibition of spontaneous emission and the a single-particle self-excited oscillator, some of which are now applicable in MRI imaging and for ICR analysis of pharmaceuticals.

2:40pm **IPF-TuA4 Nanopores & Systems Biology**, ***J.J. Kasianowicz***, *J.W.F. Robertson,* National Institute of Standards and Technology*, O.V. Krasilnikov*, UFPE, Recife, Brazil, *V.M. Stanford*, National Institute of Standards and Technology **INVITED**

Proteins that form nanometer-scale pores in cell membranes are the basis of many biological processes including nerve activity and cell-cell communication. Research over the past two decades demonstrated that they could also be used for the selective detection and characterization of molecules (e.g., proteins, anthrax toxins, and DNA). More recently, a single nanopore was used as the transducer for a novel aqueous-based mass spectrometry technique. The ability to detect and discriminate between molecules with nanopores should provide useful analytical systems for health care applications.

4:00pm **IPF-TuA8 Circuits with Light at the Nanoscale**, ***N. Engheta***, University of Pennsylvania **INVITED**

For many years, the familiar notion of lumped circuit elements has been extensively and successfully used in microelectronics. This concept has allowed "modularization" of various functions at the circuit level, and thus has been proven to be a powerful tool in design, innovation, and discovery of new functionalities in the radio frequencies (RF) and microwaves. Can the concept of lumped circuit elements, and the mathematical machinery of circuit theory, be extended into the nanometer scale and into the optical domain? In other words, can we envision nanostructures that may act as a "module" representing a lumped circuit element, such as a nanoinductor, a nanocapacitor, a nanoresistor, and a nanodiode, etc. that will work with light, instead of electricity? Utilizing the notion of metamaterials and plasmonic materials with unusual values for material parameters such as negative or near-zero parameters, we have developed the concept of lumped circuit elements at the higher frequency regimes, such as terahertz (THz), infrared (IR), and optical domains. With this approach, nanoelements such as nanoinductors, nanocapacitors, nanoresistors, and nanodiodes can indeed be envisioned at optical frequencies by properly arranging plasmonic and nonplasmonic nanostructures as a tapestry of nanoparticles. This new circuit paradigm, which we coin "meta-nanocircuits" inspired by metaplasmonics, provides us with the possibility of tailoring and manipulating optical electric fields with desired patterns in sub-wavelength regions, and thus allows the mathematical tools of circuit theory to be used in the THz, IR and optical frequencies. This will open doors to many innovations in future optical nanoelectronics and nanosystems, and may likely lead to a new paradigm for information processing, detection, and storage, in the nanometer scales. In our theoretical and computational works, we have shown how more general circuits with various transfer functions can be considered by using blocks of nanostructures, providing new ways of designing nano-scale optical lumped components and devices such as filters, switches, etc. at optical wavelengths. Such meta-nanocircuits may one day be also interfaced with biological circuits, leading to the possibility of hybrid nano-bio circuits. In this talk, I will present an overview of some of our theoretical results and computational simulations on this concept of metactronics - metamaterial electronics.

4:40pm **IPF-TuA10 Understanding the Near Earth Object Population**, ***W.F. Bottke***, Southwest Research Institute **INVITED**

Near Earth Objects (NEOs) are asteroids and comets on orbits that allow them to approach and, in some cases, strike the Earth. This population is comprised of bodies ranging in size from dust-sized fragments to objects tens of km in diameter. It is now recognized that the impact of diameter D > 0.1 km NEOs represent a small but non-negligible hazard to human life and infrastructure. Interestingly, however, the potential threat represented by these bodies may also be one of easier ones to mitigate against, provided adequate resources are allocated to identify all of the NEOs of relevant size. Using our knowledge of the collisional and dynamical mechanisms that transport asteroids and comets from their source regions all the way to NEO space, we now have a working model of the steady-state orbital, size, and albedo distributions of the NEO population. This model does an excellent job of reproducing observations from various NEO surveys (e.g., LINEAR). We predict the existence of approximately 1000 NEOs that are roughly 1 km in size. The mean impact interval for these objects with the Earth is 0.5 My, with most impactors being asteroids rather than comets. We also find that the Earth should undergo a 1000 megaton (MT) collision every 64,000 years. Only a tiny fraction of the 300 m diameter bodies capable of producing these kinds of blasts have been discovered to date. These predicted impact rates are in good agreement with the terrestrial and lunar crater record and have been confirmed by recent work. Our NEO model has recently been used to predict the future rate of NEO discoveries using current and next-generation survey technology. We find that 90% of the potentially hazardous (diameter D > 140 m) NEOs could be found within 20 years or so using new ground- or space-based surveys. The cost of these systems vary, but much can be accomplished for a budgetary equivalent to a NASA Discovery-class mission ($200-$400 million). Our understanding of the processes that produce NEOs has also led to new insights into how the terrestrial impact flux has changed over time. We can now show that large breakup events in the inner portion of the main asteroid belt may trigger so-called asteroid showers, events that can dramatically increase the impact flux on Earth for prolonged periods (e.g., in some cases for as long as 100 My). In fact, one particular breakup event occurring within the last 200 My may have had important implications for our understanding of mass extinction events and life on Earth.

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