IPF on Mesoscale Science and Technology of Materials and Metamaterials
Room: 210F - Session IPF+MS-TuA

Frontiers in Physics
Moderator: Jim Hollenhorst, Agilent, Cathy O'Riordan, AIP

2:20pm **IPF+MS-TuA1 Giving New Life to Materials for Energy, the Environment and Medicine**, ***Angela Belcher***, MIT Koch Institute for Integrative Cancer Research **INVITED**

Organisms have been making exquisite inorganic materials for over 500 million years. Although these materials have many desired physical properties such as strength, regularity, and environmental benign processing, the types of materials that organisms have evolved to work with are limited. However, there are many properties of living systems that could be potentially harnessed by researchers to make advanced technologies that are smarter, more adaptable, and that are synthesized to be compatible with the environment. One approach to designing future technologies which have some of the properties that living organisms use so well, is to evolve organisms to work with a more diverse set of building blocks. The goal is to have a DNA sequence that codes for the synthesis and assembly of any inorganic material or device. We have been successful in using evolutionarily selected peptides to control physical properties of nanocrystals and subsequently use molecular recognition and self-assembly to design biological hybrid multidimensional materials. These materials could be designed to address many scientific and technological problems in electronics, military, medicine, and energy applications. Currently we are using this technology to design new methods for building batteries, fuel cells, solar cells, carbon sequestration and storage, enhanced oil recovery, catalysis, and medical diagnostics and imaging. This talk will address conditions under which organisms first evolved to make materials and scientific approaches to move beyond naturally evolved materials to genetically imprint advanced technologies with examples in lithium ion batteries, lithium-air batteries, dye-sensitized solar cells, and ovarian cancer imaging.

3:00pm **IPF+MS-TuA3 XFEL Movies of Molecular Machines at Work**, ***John Spence***, Arizona State University **INVITED**

With about 1E12 coherent hard X-ray photons per shot of 10 fs duration at 120 Hz, the invention of the X-ray laser (XFEL) has provided many new research opportunities for stuctural biology, which I will review. Our first discovery, that these pulse are so brief that they outrun radiation damage, so that damage-free diffraction patterns at atomic resolution and femtosecond time resolution can be recorded to make movies of protein function, has proved immensely fruitful. Other advances in solution scattering, analysis of protein nano crystals, and imaging of single particles which cannot easily be crystallized, such as viruses, wll be also be reviewed. This work forms part of the activity of the NSF's BioXFEL STC, a consortium of seven US campuses devoted to the use of XFELs for Biology. (http://www.bioxfel.org).

4:20pm **IPF+MS-TuA7 Frontiers of Ocean Sensing**, ***Susan K. Avery***, Woods Hole Oceanographic Institution **INVITED**

The ocean accounts for more than two-thirds of Earth's surface and is our planet's largest biome, yet remains largely unexplored. Because seawater is opaque to most wavelengths of electromagnetic radiation, all but a few centimeters of the upper ocean are invisible to satellites. As a result, only about 5 to 15 percent of the seafloor is mapped in any detail and much of the water column has not been explored. Many of the transient phenomena that occur on, in, or above the ocean—and across a wide range of spatial and temporal scales—have been extremely difficult to capture, and even more difficult to monitor over long periods. New technologies and new adaptations of existing technologies, however, are opening the ocean in all its complexity to researchers at sea and on shore. Our challenge now is to take advantage of these innovations in sensing and observing, not only to fully grasp the role that the ocean plays in making Earth habitable, but also how it fits into planetary and societal changes that are taking place before our very eyes.

5:00pm **IPF+MS-TuA9 New States of Electronic Matter and their Potential for Science and Computation**, ***Joel Moore***, University California, Berkeley **INVITED**

A major development in solid-state physics over the past decade is the discovery of several new classes of electronic materials that combine features of metals and semiconductors in novel and potentially useful ways. "Topological insulators" are materials that insulate in bulk but have atomically thin conducting layers at their surfaces as a subtle consequence of spin-orbit coupling. "Weyl" and "Dirac" semimetals are three-dimensional materials that realize two different 3D generalizations of the massless electronic structure of graphene, a single layer of carbon atoms, whose discovery was recognized by the 2010 Nobel Prize. We explain the origin of these materials and how they might enable dissipationless electrical conduction and superconducting states with fractional "Majorana" particles.

5:40pm **IPF+MS-TuA11 The Universe in Motion: Listening to Gravitational Waves with LIGO**, ***Michael Zucker***, Massachusetts Institute of Technology **INVITED**

Almost 100 years ago, Einstein showed that traces of matter and energy's gyrations are continuously broadcast throughout the universe, in the form of *gravitational waves:* ripples in the underlying geometry of space. Fresh from a major upgrade, the Laser Interferometer Gravitational-wave Observatory (LIGO) is now poised to detect and decode these broadcasts, opening a new era of physics and astronomy. I will talk about why LIGO is so different from other observatories, and describe some of the daunting technological challenges we've overcome to help us realize Einstein's vision.

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