Distinguished Lecturer in Plasma Physics
Calendar Years 2016 and 2017

The Division of Plasma Physics of the American Physical Society is pleased to announce its Distinguished Lecturers for 2016 and 2017. This Program is intended to share with the larger scientific community the exciting recent advances in plasma physics. The Lecturers may be invited by contacting them directly and scheduling the travel.

Under the auspices of the Distinguished Lecturers Travel Grant Program funded by the U.S. Department of Energy, the Lecturers are available for talks at U.S. colleges and universities during the calendar years 2016 and 2017. Their travel expenses will be supported by the grant. No travel-related expenditure is expected from the lecture-hosting institution.

For additional info, contact Mark Koepke, West Virginia Univ., ph: 304-293-4912, email: mark.koepke@mail.wvu.edu or **http://www.apsdpp.org/outreach/lecturers.php** where the DPP publicizes the program with announcements of the speakers.

Nuclear fusion: Energy technology development with tantalizing potential to completely redefine the world's energy supply system

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Bringing the stars down to earth is one of the great scientific challenges of the 21st century. The controlled fusion of isotopes hydrogen into helium represents an essentially inexhaustible source of energy for society and remarkable progress has been made in attaining that goal by building new understanding of the still mysterious conditions inside the tokamak, the experimental test bed where fusion reactions occur at temperatures exceeding 100 million degrees. The ITER tokamak, currently under construction in France, is designed to deliver 500 megawatts of output from 50 megawatts of input power for several minutes at a time. Success would open the door to a large-scale source of continuous power with no carbon emissions or hazardous waste problems, and fuel that could largely be extracted from ordinary seawater. Work on existing tokamaks is largely focused on the grand challenges of fusion: the need to contain an ongoing fusion reaction, create a stable "burning plasma" that can maintain its own temperature, and capture its massive heat output for electric power generation. Containing a stable plasma at high temperatures is a challenge because the fusion plasma supports many waves and instabilities, some leading to turbulence, which very effectively redistributes heat and particles in the plasma, inhibiting attainment of parameters needed to achieve a burning plasma. Advanced simulations are being used to make predictions about turbulence parameters, the predictions are being compared to results from newly developed plasma turbulence diagnostics, and models of plasma confinement and performance are being developed that steer the experimental optimization of plasma confinement and control. This talk will introduce basic plasma physics behind fusion energy development, discuss science and technologies of the leading fusion plasma confinement device, the tokamak, and will describe recent advances in understanding turbulent transport from MIT's Alcator C-Mod tokamak.

Frontier science with high power lasers and high energy density plasmas

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Frontier science in the high-energy-density (HED) regime refers to the relatively recent study of the properties of macroscopic amounts of matter at conditions where the energy density is very high, namely, energy/volume > 10^{12} erg/cm^3. Such conditions correspond to matter at high density, high temperature or, in the case of electromagnetic radiation, high intensity. Such regimes can be created on high-power laser systems and on magnetic-pinch facilities and correspond to the conditions required for inertial-confinement fusion (ICF) and that occur naturally in many astrophysical systems. With the advent of modern, high-power lasers, studies in the HED regime have become possible and quite wide spread. One example of current interest in astrophysics is the study of collisionless shocks. Astrophysical collisionless shocks are ubiquitous, occurring in supernova remnants, gamma ray bursts, and protostellar jets. They appear when the ion-ion collision mean free path is much larger than the system size. Here we present laboratory experiments using high-power lasers and investigate the dynamics of high-Mach-number collisionless-shock formation in two interpenetrating, high-velocity plasma flows. It is believed that in astrophysics such shocks can generate magnetic fields on a cosmologically fast timescale via the Weibel (or filamentation) instability. Our research, in fact, does show that high-velocity interpenetrating plasma flows can generate magnetic fields. Another example is the study of basic material properties under high pressure. Yet a third example is the world-wide pursuit of ICF ignition. This Lecture will present examples from cutting-edge research performed on many HED facilities around the world and on the National Ignition Facility at Lawrence Livermore National Laboratory, the largest laser system in the world.

From sandpiles to burning plasmas: How turbulence self-organizes to facilitate fusion energy

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In spite of efforts to keep controlled fusion fuel hot, dense, and confined, particles leak, heat is lost, and gradients in plasma density and plasma temperature consequently arise, analogous to sand grains being fed from the top and tumbling down the side of a sandpile. These plasma gradients cause fluid-like plasma turbulence that enhances the tumbling, tending to relax the gradients until either turbulence or fuel is the first to go away. Therefore, more turbulence means less confinement and less fusion-energy production. Under the right dynamical conditions, these turbulent fluctuations can spontaneously organize, increase confinement efficiency, and allow extremely strong gradients to develop due to a collapse in the turbulence amplitude. As a result, reaching fusion conditions is easier to achieve. This talk describes how a combination of serendipitous experimental findings in large and small (but scaled) magnetically confined fusion experiments, theoretical breakthroughs, and high-performance computational modeling have helped fusion scientists piece together this puzzle of the processes of turbulent transport and self-organization. The results will illustrate why producing energy from fusion reactions is challenging, what next steps must be taken to produce net energy gain, and how to sketch out possible pathways to fusion energy reactors.

Low temperature plasmas for converting renewable electricity into chemical reactivity: Microelectronics, environment, healthcare

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The vision for a sustainable future is societies that are powered by renewable and clean electricity from solar, wind and fusion energies sources. This excellent vision gets you only half-way to the goal. Societies run on chemical reactivity, from syn-thesizing materials and fabricating microelectronics to energy storage and human healthcare. To enact this vision of the future, electrical power must be converted into the chemical reactivity that fuels society. Low temperature plasmas – partially ionized gases – have served in that role for many years and may be the key for enabling a future based on renewable electricity. Through energetic electron collisions with unreactive gases, solids and liquids, low temperature plasmas (LTPs) create chemical reactivity by producing radicals, ions, photons. These species are then the basis of etching or depositing materials, efficient lighting, chemical synthesis and, now, human healthcare. Perhaps the most impactful success of LTPs is their use in microelectronics fabrication – the information-technology revolution has been enabled by the materials processing abilities of LTPs. In this talk, the basis of controlling LTPs for materials synthesis and human healthcare will be discussed using examples from computational simulations. The manner of customizing LTPs using, for example, high frequency pulsed power to produce the desired reactivity using low- and high-pressure plasmas will be highlighted. The future role of LTPs in enabling a green future based on renewable electricity will be proposed.

Going where no plasma has gone before: Arrays of microcavity plasmas and their impact on lighting, water disinfection, and medical therapeutics

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The last decade has witnessed the rapid emergence of microcavity plasmas, a new subfield of plasma science and technology that pursues the fundamental physics and applications of low temperature, nonequilibrium plasma confined in at least one dimension to nominally < 1 mm. By melding plasma science with photolithography and other micro/nanofabrication techniques adapted from the integrated circuits and materials science communities, it has become possible to observe plasma behavior and realize electronic/photonic/chemical devices that were inaccessible previously. With apologies to Captain Kirk, plasmas are now able "to go where no [plasma] has gone before." This presentation will highlight several recent developments that vividly illustrate the potential of microplasma science. These include interfacing a gas phase (electron – ion) plasma with an electron – hole plasma to yield a plasma bipolar junction transistor (PBJT). Other examples are efficient microchemical reactions based upon massively parallel processing in arrays of microchannel plasmas and, secondly, a new form of thin flat lighting ("light tiles") available in sheets as large as 30 X 30 cm^2.

Stormy (space) weather: An EMFISIS on the Radiation Belt Storm Probes

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The NASA Van Allen Probes mission was launched in August of 2012 to investigate the dynamic environment of the Earth's radiation belts. The NASA twin satellite mission is flying through the Van Allen belts more than 50 years after their discovery with the most comprehensive set of instruments ever deployed in this region of space. Thought for many years to be an essentially solved problem in space plasma physics, the new measurements show that quite to the contrary, the radiation belts are a highly variable part of space that still holds many questions for active research. This talk will present the story of the evolution from mundane to hot research topic, some basics of radiation belt plasma physics, the cast of characters from killer electrons to whistler waves, and an overview of some of the most exciting results from the Van Allen Probes mission and, in particular, plasma wave results from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS).

Solar wind interactions with magnetized lighter plasma cavities and unmagnetized heavier plasma clouds in the heliosphere

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The heliosphere is a bubble of magnetic-field pressure and plasma-particle pressure immersed in the vacuum of interstellar space. The heliosphere is comprised of the tightly spiraled, outward drifting, solar magnetic field and an initially supersonic, cross-field, plasma outflow (called the solar wind) from the Sun. Dotting the heliospheric volume are pockets (plasma cavities, or magnetospheres), formed by the interaction between the solar wind with planetary magnetic fields, and obstacles (plasma clouds and/or planetary atmospheres), formed by mass-loading the solar wind passing by with ionized atmosphere. A cornerstone of research in the field of space plasma physics is understanding the deflection of the solar wind by an isolated solar system object (e.g., planet, moon, comet) and the object's complicated interaction with its local plasma environment. Common features of these interactions include an upstream (sunward) shock/wave front that slows and heats the solar wind plasma over a relatively short distance and a downstream (anti-sunward) comet-like tail that flaps and snaps dynamically over a relatively long distance of hundreds of object diameters. Forecasting the electromagnetic "space weather" events at Earth as well as interpreting what the aurorae tell us about each planet's magnetic cavity relies on the fundamental plasma processes that mediate these interactions. We will discuss plasma waves generated by solar wind interactions from Mercury to Pluto. Specific topics include magnetic-field reconnection and the generation of Kelvin-Helmholtz waves at the boundaries of the solar system objects.