The Division of Plasma Physics (DPP) of the American Physical Society is pleased to announce its Distinguished Lecturers for 2015. This Program is intended to share with the larger scientific community the exciting recent advances in plasma physics.

Under the Plasma Physics Travel Grant Program funded by the U.S. Department of Energy, the Lecturers are available for talks at U.S. colleges and universities for the year 2015. Their travel expenses will be supported by the grant. No travel-related expenditure is expected from the lecture-hosting institution.

The Lecturers may be invited by contacting them directly.

Additional information about the Distinguished Lecturer in Plasma Physics Travel Grant Program can be obtained from the Chair of the DPP Education and Outreach Committee:

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Why Should You Care about Nuclear Fusion?

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Three quick answers to the title's question: fusion energy will be a topic of discussion for your entire life; the science and engineering challenges in obtaining sustained fusion on earth are interesting; fusion connects to nearly all science in part because it is the fuel for the universe, powering all stars. The talk will define fusion and how it works in stars. The current efforts to sustain inertial and magnetic fusion in the laboratory will be summarized. The talk will describe in some detail the most interesting endeavor right now, the attempt to reach inertial fusion ignition at the National Ignition Facility in Livermore, California using the world's largest laser to drive explosion of a tiny fusion fuel target. The world's largest fusion endeavor, the International Thermonuclear Experimental Reactor (ITER) under construction in Cadarache, France, will be outlined along with the magnetic confinement of plasma that it will rely on. Connections of these fusion concepts to astrophysics and materials science will be described. Why fusion energy is so attractive and so elusive will be discussed. This is a general talk on fusion science and energy.

Laser-Driven High Energy Density Physics

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High-Energy Density (HED) physics is loosely defined as the response of matter to pressures of one million atmospheres and higher. This is a pressure range that is important for inertial confinement fusion, many astrophysical systems, and nuclear weapons. This talk will describe how high energy and high intensity lasers can create HED conditions in the laboratory and how these systems are diagnosed to understand their properties. Ablation (rocket-effect through conservation of momentum) and the generation of intense electron currents are the fundamental processes that allow the materials to be driven into HED conditions. The use of these processes in HED physics will be described, including in inertial confinement fusion, materials properties relevant to planetary interiors, hydrodynamics of astrophysical objects, and the generation of intense positron beams that are relevant to the most energetic phenomena in the universe.

Creating and Controlling High-Energy-Density Matter with the National Ignition Facility

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The National Ignition Facility (NIF), at Lawrence Livermore National Laboratory, is the world's largest laser. NIF houses 192 beams that can deliver over 1.8 MJ of ultraviolet energy and peak powers of 500 TW to a target ($<<$ cm^3). The deposition of this energy in a small volume creates extreme radiation environments and large pressures in materials. These very large pressures have been used to create unique conditions for studying the behavior of matter at high energy densities (high-energy-density matter can be defined as having pressures greater than 1,000,000 times atmospheric pressure). High energy density science is an emerging scientific field focused on the unique behavior of matter at extreme conditions. High-energy-density science is critical to our understanding of the safety and reliability of nuclear weapons, many astrophysical questions, and inertial confinement fusion. In this talk, we will provide an overview of the National Ignition Facility and discuss two areas of high-energy-density science studied on the NIF including: the properties of materials at high pressures and recent progress in inertial-confinement fusion research.

The Benefit of Coating the Plasma Facing Surfaces of Fusion Research Chambers with Low-Atomic-Number Materials in Keeping Plasma Hot, Confined, and Fusing

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Fusion energy as a practical energy source! Sounds great but how do we get there? Instructions: 1) Heat plasma to thermonuclear temperature (and check with an impressive set of 'thermometers'), 2) Keep core plasma from cooling and keep chamber wall from melting, 3) Minimize the transients that lead to concentrated wall heating, 4) Coat the wall with a low-atomic-number (low Z) material or even liquid metal for protection, 5) Extract heat, and (eventually) generate electricity.

Solid plasma-facing components made of high-Z material, e.g. tungsten and its alloys, might be marginally acceptable for reactors. On the other hand, low-Z coatings on high-Z materials or even liquid plasma-facing components (PFCs) have some beneficial properties, albeit with additional technical challenges. A few years ago, experiments in the National Spherical Torus Experiment at Princeton Plasma Physics Laboratory began to test the use of evaporated lithium (Z=3) to condition the surface layers of PFCs. These coatings both improved the core plasma, while somewhat surprisingly eliminating edge-localized instabilities in the plasma boundary. These transient, periodic instabilities normally result in bursts of concentrated heat flux and particle flux to the PFCs. Detailed analysis of the edge plasma before and during lithium usage showed a reduction of catastrophic disturbances to the ideal magneto-hydrodynamic core-plasma equilibrium, implying the elimination of the edge-localized instabilities.

This talk will highlight the differences in the edge and core plasma behavior with and without low-Z wall coatings. An introduction to fusion physics and plasma-wall interactions comprises a substantial portion of this seminar.

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.

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.

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.