The Division of Plasma Physics of the American Physical Society is pleased to announce its Distinguished Lecturers for 2013–2014. This Program is intended to share with the larger scientific community the exciting recent advances in plasma physics.

Under 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 for the academic year 2013–2014. 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?
Dave H. Crandall, Retired after 40 years experience in fusion-related physics for the Department of Energy, Washington, DC
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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.

Using Magnetic Fields to Create and Control High Energy Density Matter

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The refurbished Z facility at Sandia National Laboratories is the world's largest pulsed power driver. Z can efficiently and transiently create current as large as 26 million amperes. Such large current creates large magnetic field that, in turn, creates very large pressure. This very large pressure has been used to create unique conditions for studying the behavior of matter at high energy density (high energy density matter can be defined as having pressure 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 cover several areas of high energy density science studied on the Z facility including: the properties of material at high pressure, the behavior of plasma in an intense radiation field, the transformation of astrophysics from being mostly an observational science to one capable of being carried out also in the lab, and exciting new approaches to achieving inertial confinement fusion in the laboratory.

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 targets 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.

Self-Organization - Nature's Intelligent Design

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Complex patterns are common throughout nature, from the distribution of the galaxies in the Universe to the organization of neurons in the human brain. It is generally assumed that such complex structure must have a complex cause, but it may be that the patterns spontaneously arise through the repeated application of simple rules. This talk will provide examples of self-organization in nature and will describe six simple computer models that can replicate the features of these patterns. The models typically produce fractal spatial structure and chaotic temporal dynamics characterized by power laws and unpredictability, even when the models are simple and purely deterministic. The work has application to fields as diverse as physics, ecology, political science, economics, sociology, and art.

Novel Physics with Non-neutral Plasmas

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Nonneutral plasmas consisting of particles with only a single sign of charge (*e.g*., pureelectron, pure-positron, or pure-ion plasmas) can be confined for *days or even weeks* using the static electric and magnetic fields of a Penning trap. These novel plasma systems can access regimes unavailable to quasi-neutral plasmas. For instance, they have been cooled to cryogenic temperatures without recombination, and can even form non-neutral *liquid or crystalline* states. In this talk I will review a few aspects of the broadly varied physics accessible to these long-lasting trapped non-neutral plasmas, including applications to precision spectroscopy, quantum computing, fluid dynamics, fusion science, plasma astrophysics, and ongoing efforts to create trapped anti-hydrogen atoms.

Taming turbulence in plasmas: from magnetic fusion energy to black hole accretion disks

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Plasmas in the laboratory and in astrophysical settings vary widely in parameters (e.g. temperature and density) but have one thing in common: they are plagued by instabilities. Instabilities and associated turbulence are detrimental in laboratory plasmas for fusion energy research, causing heat, particles and momentum to "leak" across the confining magnetic field. In astrophysical plasmas like accretion disks, turbulence is essential to explain observed rates of momentum transport and accretion. I will talk about instabilities and turbulence in magnetized plasmas and their relevance to achieving magnetic confinement fusion in the laboratory and understanding processes in astrophysical plasmas.

Plasmas in Space: From the Surface of the Sun to the Orbit of the Earth

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Plasma is gas in which a portion of the atoms or molecules are ionized, and thus consist of ions and electrons as well as neutral particles. Plasmas display a richer variety of phenomena than neutral gases. Plasma physics is of importance to astronomy and astrophysics because many astronomical objects are made of plasma. In this talk, I will describe our understanding of the plasma state of the solar atmosphere and interplanetary space (also referred to as the "solar wind") between the Sun and the Earth. The solar atmosphere and interplanetary space are of interest for two reasons. First, they are important astronomical objects and media in their own right. Second, the Sun and interplanetary medium can be measured with a level of detail and precision unattainable for other astronomical objects. In the case of the interplanetary medium, we have the opportunity to make direct "ground truth" measurements of plasma parameters such as density, temperature, and all three vector components of the magnetic field. These more detailed measurements provide a clear view of physical processes that also occur elsewhere in astronomy. I will emphasize those aspects of solar and interplanetary physics that I find most intriguing, and potentially most important in a broader astronomical and astrophysical context.

These topics include remote magnetometry of the solar corona (the highest altitude in the solar atmosphere), the attempt to discover the mechanisms responsible for heating the solar corona to temperatures as high as 2 million Kelvin, and the properties of turbulence in the solar atmosphere and interplanetary space. I will conclude by showing how knowledge gained through study of the Sun and interplanetary medium can contribute to our understanding of much more remote astronomical objects in the Milky Way galaxy and beyond.

Sizing Up Plasmas using Dimensionless Parameters

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Fusion energy, an attractive long-range option for the U.S. clean-energy portfolio, is created when light atomic nuclei are fused together by heating ionized gas (called plasma) to a temperature of hundreds of millions of degrees. Such plasma can be held in place by strong magnetic fields, and while a great deal of progress has been made in understanding this complex physical system using first principle models, dimensionless analysis has also proven to be a valuable tool. This talk reviews what the scaling of phenomena with dimensionless parameters has taught us about the physics of magnetically confined fusion plasmas, and about the extrapolation of present-day experiments to future burning-plasma devices. First, the basic principles of dimensional analysis are introduced by discussing the Buckingham Π theorem and Connor-Taylor scale invariance. Second, the cornerstone principle of similarity, which prescribes that plasmas with the same dimensionless parameters but different physical size exhibit the same physical behavior, is demonstrated. Next, experiments using toroidally configured plasma (i.e., tokamaks) are described that measure the dependence of plasma turbulence and diffusion on dimensionless parameters associated with the normalized plasma size, pressure, and collision frequency. These studies show that plasma turbulence consists of mainly electrostatic fluctuations with characteristic cross-magnetic-field wavelengths on the order of the ion gyroradius (i.e. "micro-scale" turbulence), in general agreement with state-of-the-art drift-wave models. Finally, a modified "wind tunnel" approach to extrapolating dimensionless plasma behavior is discussed that points to a favorable path for increasing the fusion performance in future devices such as the international ITER burning-plasma experiment presently under construction.