Distinguished Lecturer in Plasma Physics

Calendar Years 2017-2018

The Division of Plasma Physics of the American Physical Society is pleased to announce its Distinguished Lecturers for 2017-2018. 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 2017-2018. 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.

Extreme environments at the world's most powerful pulsed x-ray sources

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The powerful x-ray outputs produced by pulsed power devices at Sandia National Laboratories provide unique opportunities to study a wide range of physics, including high energy density plasmas, opacity, material properties, radiation effects, and inertial confinement fusion. The Z accelerator is the world's most powerful source of soft x-rays and can provide upwards of 300 TW from a z-pinch load. Recent work at Z has resulted in the production of unprecedented outputs of 10-30 keV x-rays from pulsed power drivers. Higher energy photons are available at the Saturn accelerator, which utilizes diodes to produce bremsstrahlung x-rays >100 keV, and the Hermes III accelerator, which is the world's most powerful gamma ray generator. Efforts are currently underway to improve these sources and develop a path to high-yield fusion sources, which would increase the x-ray outputs further, and provide neutron capabilities. This presentation will review the current state of x-ray sources at the Sandia pulsed power facilities, discuss future facility capabilities, and highlight several of the research activities that utilize these facilities, including z-pinch physics and studies of systems and materials in extraordinarily intense radiation environments.

Fast Magnetic-Reconnection in Laboratory and Space Plasmas

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In recent years, new developments in reconnection theory have challenged classical nonlinear magnetic-reconnection models. One of these developments is the so-called plasmoid instability of thin current sheets that grows at super-Alfvenic growth rates. Within the resistive MHD model, this instability alters qualitatively the predictions of the Sweet-Parker model, leading to a new nonlinear regime of fast reconnection in which the reconnection rate itself becomes independent of S. This regime has also been seen in Hall MHD as well as fully kinetic simulations, and thus appears to be a universal feature of thin current sheet dynamics, including applications to reconnection forced by the solar wind in the heliosphere and spontaneously unstable sawtooth oscillations in tokamaks. In three dimensions, the instability produces self-generated and strongly anisotropic turbulence in which the reconnection rate for the mean-fields remain approximately at the two-dimensional value, but the energy spectra deviate significantly from anisotropic strong MHD turbulence phenomenology. A new phase diagram of fast reconnection has been proposed guiding the design of future laboratory experiments in magnetically confined and high-energy-density plasmas, and have important implications for explorations of the reconnection layer in the recently launched NASA MMS mission.

Lasers, plasmas, and the big things we could do if we had small accelerators

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One of the things that immediately impresses people about particle accelerators is how big they are. Plasma physics and laser technology could make them much, much smaller. Accelerators have become a vital part of the infrastructure of discovery science and also have a broad range of societally and commercially crucial applications in industry, security, energy, the environment and medicine. However, they tend to be large and costly and lend themselves best to fixed facilities. For many applications, the size, cost, and non-portability of accelerators are limiting factors that can lead to missed opportunities.

In a new generation of accelerators, charged particles “surf” on a wakefield created as an intense laser (or, in some designs, a driving particle beam) passes through a plasma, displacing the electrons there. The resulting electric field gradient can be up to a thousand times as intense (tens of gigavolts per meter) as that in a conventional linear accelerator based on radiofrequency power and sizable resonant cavities.

Because the electric field—the actual mechanism of acceleration in a linac—is so much stronger, these accelerators can reach energy levels in a few inches that would conventionally require machines as long as a football field. For instance, the Berkeley Lab Laser Accelerator (BELLA) Center has accelerated electrons to 4.2 GeV in a 9 cm plasma channel. Although many challenges remain, this new technology is at the brink of offering a profoundly different way to build particle accelerators with the promise of being vastly smaller and cheaper than today’s. That would open up new opportunities to deploy accelerators for discovery science, and applications, including ones where instead of bringing the problem to a national laboratory or other large central facility, we must bring the accelerator to the problem. While our ultimate goal is a high-energy physics collider, we are also exploring radiation sources such as free electron lasers and even an arthroscopic laser-plasma accelerator small enough to put into the site of a cancer, attacking it directly to minimize side effects.

In this talk, we will discuss the physics principles of the laser-plasma accelerator, the challenges and next steps as we push toward 10 GeV and beyond in multistage systems, and the wide range of spinoff applications that are already being developed.

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.

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.