APS April Meeting 2010
Washington, DC
http://www.aps.org/meetings/april/index.cfm
10:45AM P4.00001 Experimental/observational overview: what laboratory can offer to astro- and vice-versa1  MICHAEL BROWN, Swarthmore College — There has been a recent synergy among laboratory experiments, astrophysical observations, and computation models. Important progress can be made if specific problems in plasma physics can be addressed by targeted experiments, careful astrophysical observations, and well-designed computer models. I will review some of the areas in which collaborative progress has been made (magnetic reconnection, astrophysical dynamo, turbulence) then focus on two specific problems. First, ion temperatures in the turbulent high corona and solar wind are known to scale with the ion mass ($T_i \propto M_i$). Laboratory measurements of ion temperature during reconnection-driven events in the MST reversed field pinch have a one scaling ($T_i \propto \sqrt{B}$) whereas impulsive events in the SSX reconnection device have another scaling ($T_i \propto Z/M_i$). Computer simulations are being planned to help sort out the discrepancies but evidently, different physics pertains in each system. Second, solar loops can now be imaged at sub-arcsecond resolution (scales < 700 km at the solar surface). The Hinode satellite has been used to resolve structure and dynamics of solar activity to the smallest scales. Both the Caltech Solar Corona Loop Simulation Experiment and the Princeton Solar Flux Loop Experiment on MRX employ fast framing cameras to study rapid dynamics at a grid of 1200 vectors every 30 seconds. Connections among these laboratory experiments, space observations, and simulations will be emphasized.

1Supported by DOE and NSF.

11:21AM P4.00002 Large scale dynamics of laboratory and astrophysical plasmas: bridging the lab/astro scale gaps and its limitations1  XIANZHU TANG, Los Alamos National Laboratory — Large scale dynamics in a high temperature plasma tend to produce strong, large scale magnetic fields in the laboratory and astrophysical settings. It underlies two types of theory. The first is the conventional magnetic dynamo, which explains how plasma energy can be transformed into large scale magnetic energy. The second is the so-called magnetic self-organization, which explains how magnetic helicity introduced at a small scale source can be self-organized into system-scale magnetic fields. Examples of the first kind include the self-generated magnetic field in an inertially confined (ICF) plasma and the magnetic field in the accretion disk of stellar objects. The second kind includes the dramatic example of the megaparsec-scale radio lobe magnetic fields which are powered by the parsec-scale accretion disk of supermassive black holes, and the laboratory formation of spheromak and reversed field pinch by electrostatic helicity injection. Despite the huge scale separation between laboratory and astrophysical cases, the underlying physics appear to be surprisingly robust. Here I will first describe the theory of magnetic self-organization, and illustrate how a radio lobe can be formed and how it relates to the spheromak experiment. Specifically, the required extremely high efficiency in transferring gravitational infall energy into large scale radio lobe magnetic fields will be understood as the result of a resonant coupling between accretion disk and radio lobe plasma, similar to a driven oscillator. The second part of the talk concerns a new form of kinetic magnetic dynamo, which is the result of anisotropic transport when hot plasma meet a colder boundary. I will describe the underlying physical mechanisms and their laboratory and astrophysical implications. Since kinetic transport physics plays a decisive role in determining large scale dynamics, we are confounded with the interesting and difficult question of how to most effectively incorporate such physics in macro-modeling, especially in the case of nearly collisionless astrophysical plasmas.

1Work supported by DOE Office of Fusion Energy Sciences and LANL LDRD.

11:57AM P4.00003 Gyrokinetics in astrophysics — from tokamaks to galaxies  WILLIAM DORLAND, University of Maryland — Gyrokinetic is a first principles theory for the dynamics and thermodynamics of magnetized, ionized gas. It has been developed over the last three decades, primarily in the magnetic confinement fusion community, where it is widely used to interpret observations and to design experimental devices and operational scenarios. Gyrokinetic simulations of instabilities and turbulence in hot, rarefied plasma have been tested carefully in these laboratory settings. Recently, gyrokinetic ideas and codes have been successfully used to explain long-standing and otherwise puzzling observations of turbulent fluctuations in the solar wind. While magnetohydrodynamics remains the appropriate theory for dynamics in larger, truly astrophysical plasmas (such as galaxy cluster plasmas), the appropriate framework for the study of many interesting thermodynamic processes in astrophysics (such as turbulent heating and transport) is gyrokinetics. Example applications will be shown.

Monday, February 15, 2010 1:30PM - 3:06PM –  Session Q10 DPP: Plasma Physics  Maryland B

1:30PM Q10.00001 Well Confined High Density Plasma Sources\textsuperscript{1}. A. BIANCHI, ANSALDO, B. COPPI, MIT — The physics of high density plasmas ($n_0 \approx 5 \times 10^{14} - 10^{15}$ cm$^{-1}$) that can be well confined in high magnetic field, compact machines, and that can be developed into interesting neutron sources is discussed. Ignitor\textsuperscript{[1]}, a machine following a line of which Alcator was the prototype, that has been conceived and designed in order to demonstrate ignition of a D-T burning plasma, can produce up to 3 x 10$^{19}$ n/sec although with too low a duty cycle. Therefore, a non-igniting, differently conceived device with an adequate duty cycle is being analyzed. An important element for this is the development of cables involving the recently discovered MgB$_2$ superconducting material for which the He-gas cryogenic system designed for Ignitor can be adopted. The two largest polaroid (vertical) field coils for Ignitor are in fact designed with these kind of cables. We propose extending the adoption of this material for other magnet systems through a hybrid solution, in contrast to the pure copper solution adopted for Ignitor, taking advantage of the higher current densities that MgB$_2$ can sustain, and of the structural characteristics of the relevant cables.


\textsuperscript{1}Sponsored in part by the U.S. Department of Energy.

1:42PM Q10.00002 The Effect of SF$_6$ dilution in an Argon plasma  SUDIP KOIRALA, Microelectronics-Photonics Graduate Program, MATT GORDON, Mechanical Engineering, University of Arkansas, Fayetteville, AR 72701 — Plasma etching is widely used in semiconductor industries. There have been extensive studies in the dilution of rare gases; however, limited studies are found in the dilution of electronegative gases. In this work, SF$_6$ content is varied from 5% to 60% in an Ar plasma in a deep reactive ion etching system. A Langmuir probe is used to measure electron temperature ($T_e$), electron density ($n_e$), and electron energy distribution function (eedf). $T_e$ decreases monotonically with increasing SF$_6$ at first, and then increases for SF$_6$ content greater than 20%. This increase is attributed to the loss of low energy electrons in attachment and high energy electrons in excitation and ionization. As the content of SF$_6$ is increased above 20%, the dissociation of SF$_6$ increases and most of the low energy electrons are lost in attachment and hence the average electron temperature increases. $n_e$ decreases by an order of magnitude as the SF$_6$ dilution is increased from 5% to 60%, eedf shows that the distribution shifts towards high energy with the increase of SF$_6$ content, which is because of the depletion of low energy electrons.
1:54PM Q10.00003 Recent Discoveries on the Plasma Environment of Mars as seen by the Radar Sounder on MARS EXPRESS Spacecraft, FIRDEVS DURU, DONALD A. GURNETT, DAVID D. MORGAN, The University of Iowa — Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS), which is a low-frequency radar on Mars Express, is designed to study the subsurface and ionosphere of Mars. Here, we give an overview of the plasma environment of Mars as seen by MARSIS. With MARSIS, it is possible to obtain the electron densities with both remote sounding and local electron plasma oscillations. Remote sounding of the ionosphere revealed several types of echoes, including oblique echoes which arise from upward bulges in the ionosphere in regions where the crustal magnetic field of Mars is strong and nearly vertical. It is observed that the electron density profiles are in agreement with the Chapman photo-equilibrium model. Local density data revealed steep, transient electron density gradients similar to the ionopause commonly observed at Venus. It also showed that, at altitudes above 300 km, the electron density on the dayside is almost constant at a given altitude range and it increases exponentially with increasing altitude at a fixed solar zenith angle range.

2:06PM Q10.00004 Passive, precise plasma jet experiments on the sky1, PHILIPP KRONBERG, Los Alamos National Laboratory — The typical plasma parameter space has been established for the most luminous, collimated jets in the Universe. They are magnetically dominated energy pipes produced by super-massive black holes, with energy flows in excess of ~ 10^{42} erg s^{-1}, over supra-galaxy scales. I discuss these jets with examples, and conclude that all current radio telescopes fall short in resolution to provide the important plasma diagnostics in these systems. The solution is within technological reach, if the full imaging resolution of the Enhanced VLA (EVLA) were increased from the current 35 km to a few hundred km. This can be achieved by additional telescopes (ca. 6) in the State of New Mexico. The cost of doing this, ~ $200M, is modest when matched against the potential benefits to plasma and fusion science.

2:18PM Q10.00005 Observational signatures of sub-Larmor scale magnetic fields in astrophysical objects and HEAD lab experiments1, MIKHAIL MEDVEDEV, Institute for Advanced Study, Niels Bohr Institute & University of Kansas — An extensive body of studies indicate that small-scale (sub-Larmor-scale) magnetic turbulence are produced at relativistic shocks, in reconnection events and other high-energy density environments. Here we present a general description of radiation produced by relativistic electrons moving in such fields and stress its non-synchrotron spectral characteristics. We illustrate the results with spectral data from gamma-ray burst observations.

2:30PM Q10.00006 Stimulated Brillouin Scattering from OMEGA gas-filled hohlraums and NIF hohlraums with gold-boron layers, RICHARD BERGER, L. DIVOL, D. FROULA, S. GLENZER, J. KLINE, P. MICHEL, D. CALLAHAN, D. HINKEL, R. LONDON, N. MEEZAN, L. SUTER, E. WILLIAMS, Lawrence Livermore National Laboratory — The long laser pulse length required to achieve ignition on the National Ignition Facility (NIF) creates long scalelength, hot, high-Z plasma inside the hohlraum from which stimulated Brillouin scatter (SBS) is predicted to be greater than 10%. We predicted that adding ~40% Boron to a thin layer of the high-Z wall reduces the predicted SBS to less than 1%. In the past few years, a number of experiments at the OMEGA laser facility have tested elements of the physics of SBS in gold-boron and the modeling tools. The damping rates for plasmas with various gold-boron mixtures were duplicated with mixtures of CO_2 and hydrocarbon gases. Use of the rad-hydro code HYDRA for bulk plasma parameters and the paraxial-wave-solver pF3d allowed the measured levels of stimulated Brillouin backscatter in the OMEGA experiments to be predicted in advance of the experiments. Although the SBS increases with the average gain as expected, closer examination shows that, for the same gain, plasmas with very weakly damped ion acoustic waves Brillouin scatter more strongly than plasmas with more strongly damped ion acoustic waves. The pF3d simulations also show that behavior. SBS from NIF hohlraums with gold-boron layers will be presented.

2:42PM Q10.00007 Numerical Simulations of Pair Production by Ultraintense Lasers, EDISON LIANG, ALEXANDER HENDERSON, PABLO YEPES, Rice University, HUI CHEN, SCOTT WILKS, Lawrence Livermore National Laboratory — Using a combination of particle-in-cell plasma kinetic codes and the CERN GEANT4 code for pair production, we systematically study the pair production by ultraintense lasers irradiating gold targets. We will present results for the pair production yield and spectra as a function of laser and target parameters, and compare simulation results with recent data from Titan and other laser experiments. Using these we will design future experiments to optimize the pair yield and pair density. Potential applications of these results to both laboratory astrophysics and high density positronium physics will be discussed.

2:54PM Q10.00008 Monte Carlo Mathematical Modeling and Analysis of Optogalvanic Waveforms for 1s_5-2p_j (j = 7,8,9) transitions of Neon in a Hollow Cathode Discharge, KAYODE OGUNGBEMI, Howard University, XIANMING HAN, Butler University, PRABHAKAR MISRA, Howard University — The laser optogalvanic (OG) waveforms associated with the 1s_5 - 2p_j (j=7,8,9) transitions of neon in a hollow discharge lamp have been investigated as a function of discharge current (2.0 – 19.0 mA). We have defined a mathematical model in determining the amplitudes, decay constants, and time constants associated with these transitions. Monte Carlo least-squares fitting of these waveforms has helped us to specifically determine the decay rate constant (α_j), exponential rates (β_j) and time constant (τ) parameters associated with the evolution of the OG signals. In our investigation of the 1s_5 - 2p_j (j=7,8,9) optogalvanic transitions of neon, we have measured the intensity of each transition (3.65*10^{-28} – 1.43*10^{-27} and 5.82*10^{-27} cm^{-1}mole^{-1}cm^{-2}, respectively), which in turn has provided insight into the excitation temperature of the plasma (estimated to be 2847±285 K). The population distribution of the excited neon atoms in the pertinent energy levels has also been estimated using the Heisenberg Uncertainty Principle.