Who’s Doing What?

Plasma Physics and Research Experiments

in the

Laboratory for Plasma and Fusion Energy Studies (LPF)

1979 – 1987

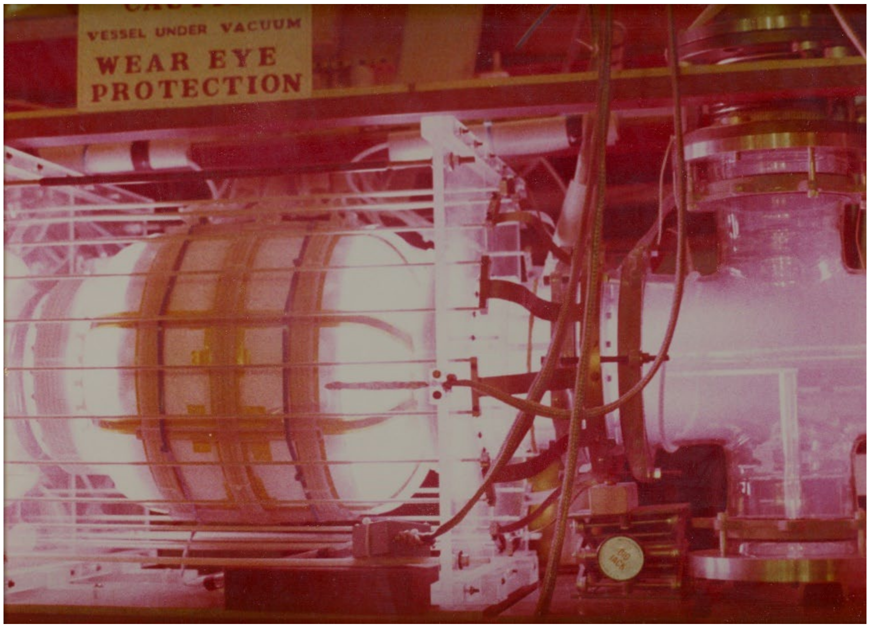
Who's Doing What?

PLASMA PHYSICS

This group is a major part of the newly formed Laboratory for Plasma and Fusion Energy Studies (LPF), and there is a close interplay of experimental and theoretical research on high temperature plasmas. Applications include both magnetic and inertial confinement for controlled thermonuclear fusion, space plasmas, and astrophysics. Besides ten teaching faculty members and their students, there are about twenty research associates engaged in the research programs described below.

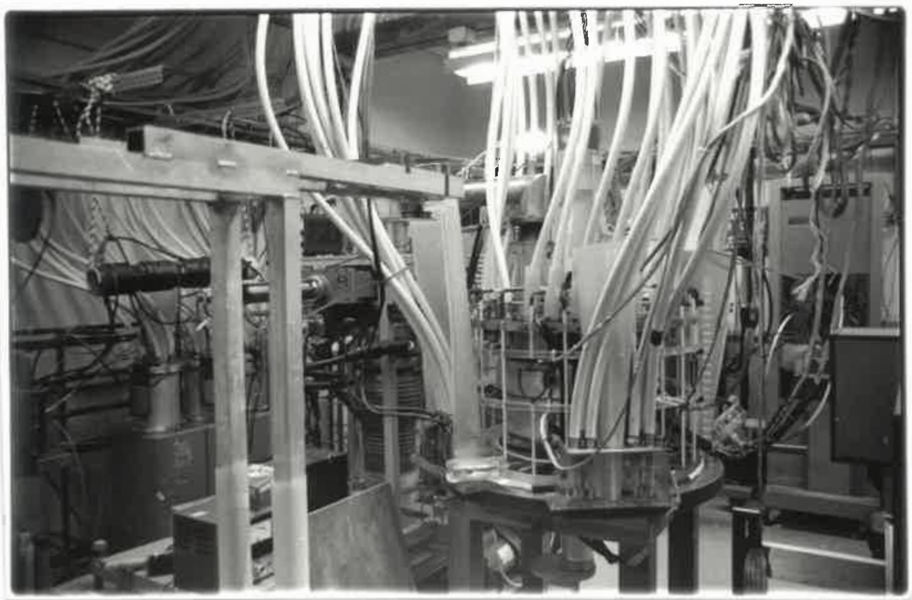
EXPERIMENTS

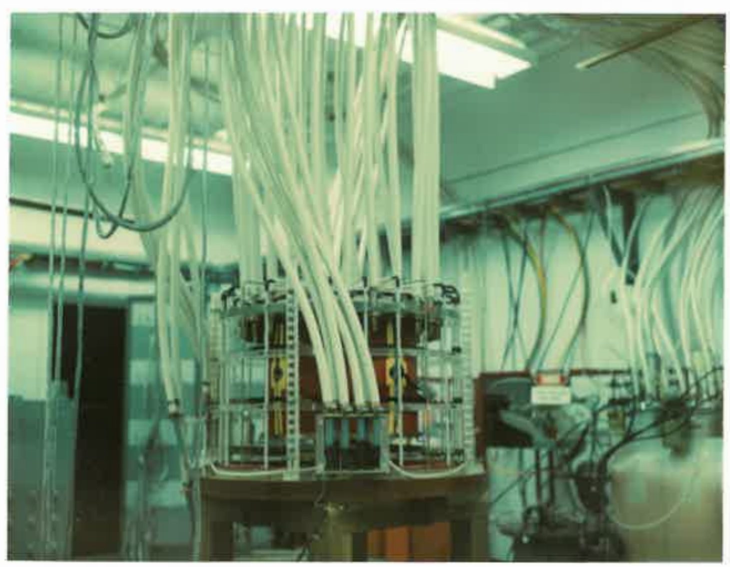
<u>Magnetic Confinement (Professors Goldenbaum, DeSilva, and Griem).</u> The production and containment of hydrogen or deuterium plasmas is investigated in various plasma-field configurations. One approach is the SPHEROMAK, in which both toroidal and poloidal fields are maintained by plasma currents. In another experiment, TERP, the toroidal field is generated by coil currents, resulting in a high beta tokamak. In both devices, questions of plasma stability and transport are studied to assess prospects for thermonuclear reactors based on these configurations.

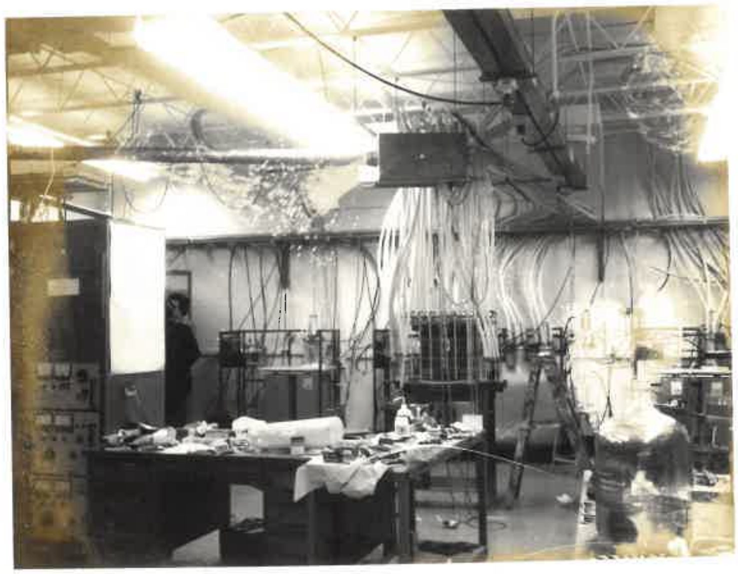


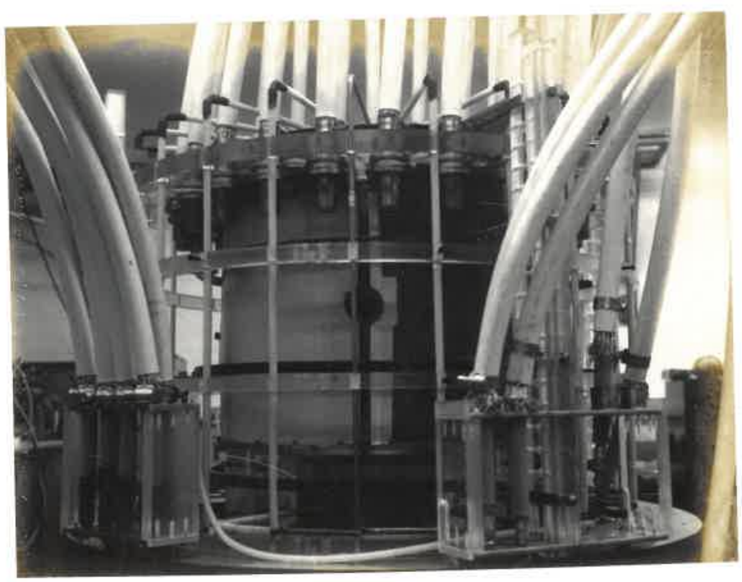
Spheromak 1984

TERP Experiment - 1978









Magnetic Mirror Experiments (Professors Boyd and Ellis). In these experiments, plasma flow along open field lines is inhibited by regions of strong magnetic field near the ends of the magnetic bottle. The emphasis in our experiments is on microinstabilities and their influence on losses through the confining magnetic mirrors, and on electron cyclotron emission diagnostics.

Electron Cyclotron Emission (Professor Boyd). Due to relativistic effects, hot magnetized plasmas emit strongly near harmonics of the fundamental electron cyclotron frequency and the spectrum is significantly modified by absorption and re-emission. We measure the resulting radiation emitted from large tokamaks at Princeton, the Elmo Bumpy Torus at Oak Ridge, and the Maryland Mirror Machine and relate the spectrum to plasma properties and radiative energy losses.

Density Fluctuations (Professor DeSilva). In dense plasmas, charged particles and electric fields are strongly coupled. Such systems are not well described by the usual kinetic theory approaches, but are important for our understanding of hot and dense matter, e.g., in stellar interiors. We measure the density fluctuation spectrum by light scattering to test theoretical descriptions of this strongly coupled manybody system, whose basic (Coulomb) forces are exactly known.

Electric Field Fluctuations (Professor Griem). Turbulent plasmas contain a much higher level of electric field fluctuations than would be expected from thermodynamic considerations. These fluctuations have a direct effect on energy and particle transport and also on the emission of radiation. To relate effective transport coefficients with microinstability theory, we are making direct measurements of the fluctuation level using laser spectroscopy.

Anomalous Resistivity (Professor Ellis). An experimental program is being launched to investigate transport in weakly ionized plasmas for the case where a moderate strength electric field is applied perpendicular to a magnetic field. The regime under investigation is characterized by strongly magnetized electrons and unmagnetized ions. It is expected that space charge effects, ionization, and instability-generated transport (anomalous transport) will all be important components of the problem. The experiment will be performed in a low density discharge plasma source with an emphasis on detailed measurements and extensive diagnostics.

Highly Charged Ions (Professor Griem). Because of the high electron temperatures and densities in reasonably well-confined plasmas, impurity atoms are rather highly stripped. However, as long as any bound electrons remain, they are also giving off copious line radiation which is undesirable in the central region of a fusion plasma but beneficial in the outer region. The radiation cooling of the latter region helps to reduce wall bombardment by energetic particles which are especially effective in sputtering, etc., of the first material wall adjacent to the magnetized plasma. Using quantitative soft x-ray spectroscopy and Thomson scattering diagnostics, we investigate the atomic physics of highly charged iron ions to provide basic electron-ion collision data for fusion research and astrophysics.

THEORY

Theoretical plasma physics research (Professors Chen, Lee, Liu, Ott, and Papadopoulos) encompasses a broad range of pure and applied subjects. Topics of current interest include studies of microinstabilities and anomalous transport, magnetohydrodynamic processes, nonlinear phenomena, the theory of confinement and heating in various controlled thermonuclear devices, and plasma processes in the solar wind and the earth's magnetosphere. Special emphasis is also given to theoretical work in support of University of Maryland experiments. A <u>sample</u> of typical current theoretical research activities follows.

<u>Microinstabilities and Anomalous Transport (Professors Lee, Liu, Ott, and Papadopoulos and Drs. Gladd and Drake)</u>. Instabilities driven by plasma nonuniformities (e.g., drift waves), velocity space anisotropy, etc., play a fundamental role in a wide variety of plasma situations ranging from tokamaks to the earth's bow shock. Intensive efforts identifying such instabilities and their consequences are currently underway by our group. An example is recent work on temperature gradient driven drift tearing modes, where it was found that these

modes, which lead to fine-scale destruction of magnetic field line topologies, could explain the anomalously high electron thermal conductivity in tokamaks. Other developments include instability studies with applications to spheromaks, reversed field pinches, mirrors, and bumpy torus.

Computer Simulation (Drs. Gladd and Winske). Computer capabilities include terminal access to the most sophisticated scientific computers available. Examples of current computer-oriented work include particle simulations of plasmas (in which plasma behavior is studied by solving F = ma for many particles), simulation of the formation of spheromak equilibria, and studies of MHD stability of spheromaks (the latter two involve solution of time-dependent partial differential equations).

Nonlinear Phenomena (Professors Chen, Lee, Liu, Ott, and Papadopoulos). Recently, it has been found that certain of the most basic equations describing nonlinear evolution of plasmas (and other physical systems) are exactly solvable by inverse scattering techniques. Basic developments in this field are being pursued at Maryland and applications to laser fusion have been made. In addition, the theory of plasma turbulence is of great interest. For example, current work on this topic includes an application of recent mathematical developments related to strange attractors.

Space Plasmas (Professor Papadopoulos). Interest in space plasmas includes the basic problem of determining the structure of the collisionless box shock formed when the solar wind impinges on the earth, plasma waves and turbulence in the solar wind, solar radio emissions, magnetosphere storms, modeling of solar flares, plasma processes on auroral field lines, etc.

PLASMA FACULTY

Teaching Faculty

D. A. Boyd

H. H. Chen

A. DeSilva

R. Ellis

G. Goldenbaum

H. Griem

Y. C. Lee

C. S. Liu

E. Ott (also EE)

D. Papadopoulos (Astronomy)

Research Faculty

M. Blaha

A. Bondeson

H. Bruhns

C. Chin-Fatt

Y. P. Chong

R. Datla

J. Drake

N. T. Gladd

P. Guzdar

A. Hassam

R. A. Hess

R. Kleva

L. Lee

R. Mahon

A. Reiman

H. Rowland

F. Stauffer

G. Tsakiris

V. K. Tripathi

D. Winske