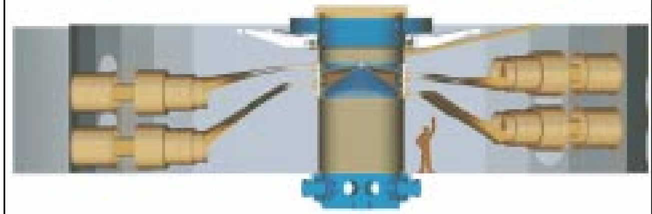
April 1996 Highlights of the Pulsed Power Inertial Confinement Fusion Program



Schematic of PBFA Z (z-pinch) configuration hardware for magnetically imploding plasma studies. The modifications extend radially outward into the water section of the pulsed power generator.

We completed the first extraction ion diode experimental series on PBFA II and began assembly of the hardware for the PBFA-Z (z-pinch) configuration.

On April 24 the first series in the extraction ion diode (PBFA X) mode ended before beginning modifications to enable z-pinch-driven implosions (PBFA Z). The first shot in an extraction geometry was June 30, 1995 with an electron beam blade load to test the power flow. The first of 86 extraction ion diode shots was September 29. This ten-month experimental series showed the operational advantages of an extraction diode. Previously--from December 11, 1985 to May 22, 1995--PBFA II operated with a barrel-shaped, radially-focusing diode. Features of the extraction diode operation included a higher vacuum (10^{-6} torr compared to 10^{-5} torr), better optical and diagnostic access, a faster shot rate (a maximum of four per day), and better power coupling of the diode to the accelerator. Using our computational tools (TWOQUICK, ATHETA, and QUICKSILVER), progress was made in optimizing the diode magnetic field to obtain a uniform current distribution, which is critical for extraction geometry. Discharge cleaning that had previously been developed on SABRE and tested on PBFA II in the radial mode significantly improved the diode impedance history. Future ion beam experiments will use the SABRE pulsed-power generator to develop active lithium sources and to reduce lithium divergence.

Numerical modeling of the Saturn annular wire-array z-pinch implosions suggests another important quantity, in addition to the circumferential gap between adjacent wires, that can affect the implosion symmetry. If the current carried per wire is too high, the individual wire plasmas will implode as separate wires instead of expanding and merging into a cylindrical shell of plasma. A greater number of individual wires may therefore be required for the higher current (20 MA) PBFA-Z. The presence of prepulse is also important: with twice the prepulse, half the number of wires is needed to obtain the same merger of individual wire plasmas.

In Saturn hohlraum experiments during April, LLNL personnel measured the opacity of iron at low density and temperature. High spectral and spatial resolution, combined with a large, homogeneous plasma source lasting tens of nanoseconds and a Planckian radiation field, provided opacity data over a large dynamic range (a factor of 100). LLNL has compared the data with their OPAL code, which calculates lower values for the Rosseland mean opacity. Improvements to OPAL, based on the new data, will have a significant effect on stellar atmosphere modeling of Cepheid variables. Similar opacity measurements could improve models of indirect-drive ICF target dynamics.

The MAP (Magnetically confined Anode Plasma) diode is an extraction ion diode that must operate for long lifetimes (10^6 shots between maintenance) at repetition rates ranging from 5 to 100 Hz. (For ICF energy applications, the repetition rate would be 4 Hz.) A fast-rising magnetic field ionizes the gas and positions the plasma for extraction. The principal shortcoming of the MAP design has been erosion of the anode electrodes from electron loss. This erosion limits the diode lifetime and creates debris that can contaminate surfaces. Recently, use of a large anode-cathode gap (10 mm instead of 7.5 mm) has dramatically reduced the debris. The reduction in anode damage suggests that, when combined with control of thermal excursions, the required lifetimes can be obtained.

The first shot on the new applied-B proton diode for Gamble II at NRL was taken the last week of April. This large area diode with a shaped anode will provide a controlled shallow focus for self-pinched transport experiments. Simulations of the planned transport experiments have been done with the 3-D, electromagnetic, hybrid (mixed fluid and particle) code IPROP. The simulations predict self-pinched propagation of a 50-kA beam in 10 mtorr argon.

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