Promising ICF capsule experiments at Sandia National Laboratories

Researchers at Sandia National Laboratories have used x-rays from powerful z-pinches on the Z-machine to implode a variety of inertial confinement fusion (ICF) capsules. In ICF experiments that use two z-pinches to heat a central hohlraum (radiation enclosure) that encloses a spherical capsule, they have demonstrated the capability to implode the capsules with a high degree of symmetry. The Z-Beamlet laser was used to produce radiographs (x-ray pictures) of these capsule implosions. The radiographs show that the capsules have been imploded to less than 1/10 of their initial size, reaching compressed shell densities that are record achievements for a pulsed power system. These experiments have also demonstrated that the radiation symmetry on these capsules is within 2 to 3 times that required to scale to large net energy production (high yield). These results are in good agreement with numerical models of radiation transport and capsule implosions.

In another set of ICF experiments where the ICF capsule was placed inside a high-temperature x-ray source created by colliding a high-speed z-pinch onto a low-density foam cylinder, they measured the first significant production of D-D neutrons associated with a z-pinch-driven capsule implosion. Simultaneously, they observed K-shell spectra from an argon dopant in the hot, dense fuel, enabling them to diagnose the fuel density and temperature as well as make important core symmetry measurements. The 2-mm-diameter plastic shells absorbed ~24 kJ of x-ray energy, the most ever for an indirect drive ICF capsule. The argon K-shell spectra that were obtained are consistent with the temperature and density conditions where fusion reactions between deuterium nuclei begin to produce significant numbers of neutrons. The x-ray pinhole camera images show that the imploded core was reasonably symmetric.

These successful ICF capsule experiments are an important step towards ignition, high yield, and inertial fusion energy with pulsed power driven z-pinch x-ray sources. Guy Bennett will describe the symmetric capsule implosions in an invited paper (RI1.002) and Roger Vesey will discuss radiation symmetry control in hohlraums in an invited paper (RI1.003). Mike Cuneo (GO2.006) will address details of experiments to optimize radiation symmetry. Steve Slutz will discuss the results of the ICF capsule experiments in an invited paper (LI2.006) while talks by Gordon Chandler (GO2.001) and Jim Bailey (GO2.002) will address details of the dynamic hohlraum x-ray source and the analysis of the argon spectra obtained from the capsule implosions. In a related poster, Dave Hanson (KP1.145) will describe the first hemispherical capsule implosions relevant to fast ignitor research on Z. (Contact: Tom Mehlhorn, tamehlh@sandia.gov, 505-845-7266 or John Porter, jlporte@sandia.gov, 505-845-7526)

Photograph of z-pinch-driven ICF capsule (on Lincoln penny)

X-ray images of imploding capsule