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High gain inertial confinement fusion will most readily be achieved with hot spot ignition[1], where a small mass of gaseous fuel is compressed to a high density and heated to ~10 keV, igniting a cooler, surrounding fuel. Recent laser driven implosions have achieved high shell density but without a well defined hot spot. X-ray driven implosions require high hohlraum drive pressure and symmetry. Eight years of experiments on Nova have led to a relatively comprehensive understanding of the energetics and symmetry of laser heated hohlraums. Relatively simple models can explain most of the features observed in our experiments. Detailed 2-D Lasnex simulations satisfactorily reproduce Nova's drive and symmetry scaling data bases, giving it credibility as a target design tool for the proposed National Ignition Facility (NIF). Implosion experiments achieved high convergence ratios (initial capsule radius/final fuel radius) in the range required for ignition scale capsules, and resulted in an imploded configuration of high density glass with hot gas fill, equivalent to the hot spot configuration of ignition scale capsules.

Nova hohlraums are typically 2.5 mm long, 1.6 mm diameter, gold cylinder with five laser beams entering through holes in the two circular surfaces. The laser entrance holes have diameters typically 50-75% of the hohlraum diameter. Radiation temperature is measured by measuring the absolute x-ray flux escaping from a diagnostic hole and by measuring the velocity of a radiation driven shock traveling through an aluminum "witness plate" mounted on the side of a hohlraum. Pure gold hohlraums as well as gold hohlraums lined with thin layers of either nickel or plastic have been used. Complementing these integrated experiments are detailed experiments to separately measure both wall losses and x-ray production in laser heated hohlraums. Overall, our modeling of all these experiments agrees well with the observations and provides insight into the physics of drive in laser heated hohlraums. A variety of pure gold drive experiments corroborate predicted high conversion efficiency in hohlraums. The decrease in drive caused by a low Z liner is due to more energy in the blow-off plasma which, in turn, is due principally to the higher specific heat of a full ionized, low Z plasma.

We have also shot on Nova more than nine symmetry scaling data bases. We accurately predict how we must change Nova's beam pointing in order to achieve best symmetry with various pulse shapes. The need to change pointing with different pulse shapes is a result of motion of the laser deposition/hot spot emission region toward smaller polar angle (when viewed from the capsule position), caused by bulk plasma evolution. Complementing direct symmetry measurements, we have also directly observed the hot spots in hohlraums in agreement with calculations.

Our best implosion targets were x-ray driven, 180 μm o.d., 5 μm thick gas filled glass microballoons overcoated with 37 μm of plastic. Fill pressures varied from 25-200 atm of deuterium. Ten Nova beams (21 kJ, 0.35 μm) produced a uniform x-ray flux on the capsule surface. The radiation brightness temperature had a 100 eV foot, rising to 210 eV peak, 1.6 nsec. chosen to optimize the pressure-density trajectory of the capsule compression, giving eight. Mbar ablation pressure at the foot of the pulse and 110 Mbar at the peak of the pulse.

Convergence of these capsules is limited by the x-ray drive symmetry both inherent to the hohlraum and due to random variations from imprecise laser beam-to-beam power balance and pointing. We maintain tolerances of 8% (RMS) beam-to-beam power balance during the foot of the laser pulse and 4% power balance during the peak, giving an x-ray power balance on the capsule uniform to 2% (RMS) at peak power and 4% in the foot.

Burn averaged fuel density and capsule convergence were determined from measurement of fuel areal density, giving densities up to 19 ± 1.5 gm/cm^3, with convergences up to 24, in agreement with simulations. Primary neutron yield, pusher areal density, burn duration, beam time, and fuel ion temperature were also measured.

Primary neutron yields for these implosions were in agreement with simulations using the Haan mix model [2]. Measured fuel ion temperatures were 0.9 ± 0.4 keV corresponding to a final fuel pressure of 16 Gbar. Glass shell densities were measured at 160 ± 20 g/cm^3. The burn duration for the 100 atm capsules was measured to be 50 ± 15 ps giving measured values of $n\tau = 1.9 \times 10^{14}$ s/cm^3.

In conclusion, the x-ray temperature and degree of symmetry in Nova implosions are accurately modeled. X-ray driven implosion have demonstrated radial convergences at a level close to the convergences required for a ignition capsules.

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