IGNITION HOHLRAUM SIMULATIONS WITH IMPOSED MAGNETIC FIELD, AND EFFECT ON HOT ELECTRONS


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We present simulations with the radiation-hydrodynamics code HYDRA [1] of ignition-scale hohlraums with an initial axial magnetic field of up to 70 Tesla. Such a field is being considered as a way to improve capsule performance by reducing electron heat and alpha particle losses from the hotspot, and possibly mitigating Rayleigh-Taylor instability [2]. The field also affects hohlraum conditions, primarily by reducing electron heat conduction. For a 4-shock “low-foot” NIF implosion, we find the imposed field increases the underdense fill temperature, and reduces the density on the equator between the capsule and high-Z wall. This allows the inner beams to better propagate to the wall, and increases the Legendre mode $P_2$ of the implosion, e.g. reduces its oblateness. The higher fill temperature may also reduce stimulated Raman scattering (SRS), by increasing Landau damping of the Langmuir wave.

Superthermal or “hot” electron propagation has also been studied, using the hybrid-PIC code ZUMA [3,4]. During the early-time “picket”, a hot electron source in the laser entrance hole with temperature $T_h=80$ keV (relevant to two-plasmon decay) deposits 0.2% of its energy in DT ice. A 70 T axial magnetic field strongly magnetizes the hot electrons in the underdense hohlraum fill gas, and guides them to the capsule. This increases the energy deposited into DT ice by $\sim12x$, and is mostly deposited in the poles (giving an asymmetric preheat). This may still be acceptable, given judicious picket pulse shaping to reduce hot electron production. During early peak power (18 ns, see figures below), hot electrons need a minimum energy of 130 keV to penetrate the ablator and deposit in the DT. Without a B field, an SRS-relevant hot electron source with $T_h=30$ keV deposits $\sim10^{-4}$ of its energy into DT ice. An initial 70 T field gets distorted during the implosion, largely following the MHD frozen-in law. The resulting field at peak power confines hot electrons to the fill gas, and reduces their coupling to DT ice by $\sim94x$.

Magnetic field from Hydra (left) and hot electron energy deposition from Zuma (right) at time 18 ns (early peak power)

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