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INTEGRATED RADIATION-MAGNETO-HYDRODYNAMIC SIMULATIONS OF MAGNETIZED BURNING PLASMAS*

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Abstract. Considering recent breakthroughs (Abu-Shawareb et al. 2022, 2024) in inertial confinement fusion (ICF), first achieving ignition conditions in National Ignition Facility (NIF) shot N210808 and then laser energy breakeven in N221204, modeling efforts have been investigating the effect of imposed magnetic fields on integrated simulations of igniting systems. Previous NIF experiments have shown fusion yield and hotspot temperature to increase in magnetized gas-filled capsules (Moody et al. 2022) in line with expected scalings (Walsh et al. 2022). We use the 2D radiation-magneto-hydrodynamics code Lasnex within the Lasnex Hohlraum Template (LHT) ICF common model (Strozzi et al. 2024). Simulations are tuned to approximate data from unmagnetized experiments: the laser power vs. time is modified to match shock velocities and nuclear bangtime, the CBET saturation clamp and cone fraction are chosen to match the P2 Legendre mode of the hotspot self-emission, and mix models for hotspot degradation to match yield.

Investigated here is the effect of imposed axial fields up to 100 Tesla on the fusion output of historically best performing ICF shots, specifically N180128 (record BigFoot shot), N210808, and N221204. The main effect is increased hotspot temperature due to magnetic insulation, as electron heat flow is constrained perpendicular to the magnetic field and alpha particle trajectories transition to gyro-orbits. Magnetic fields must be fastidiously applied however as magnetic pressure can resist the implosion and fields can decrease the propagation speed of the burn wave (Lindemuth et al. 1983, Jones et al. 1986). In conclusion it is found that magnetization can increase ion temperature by 50% and neutron yield by 5x.

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