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The Design of "Hybrid-E," the first igniting indirect-drive inertial fusion target

A.L. Kritcher

The inertial fusion community have been working towards ignition for decades, since the idea of inertial confinement fusion (ICF) was first proposed by Nuckolls, et al., in 1972 [1]. On August 8, 2021, ignition was finally demonstrated in the laboratory on the National Ignition Facility (NIF) in Northern California. The experiment, N210808, produced a fusion yield of 1.35 MJ from 1.9 MJ of laser energy and appears to have crossed the tipping-point of thermodynamic instability according to several ignition metrics.

The "indirect" ICF approach at NIF described in this talk uses a hohlraum radiation cavity to heat and ablate the outside of a capsule that contains Deuterium-Tritium (DT) fusion fuel. This ablation causes the fuel to accelerate inward (implode) at extreme velocities doing work on a central lower density "hot spot" of DT fuel, increasing the temperature and density of the hot spot to the extreme conditions required for fusion. High hot spot densities are required to trap the fusion products (alpha particles) for additional "self" heating of the plasma. If sufficient hot spot pressures and energies can be reached, the "self-heating" of the hot spot will rapidly increase hot spot temperature well beyond the mechanical work done on the implosion and ignite propagating burn into the surrounding DT fuel.

This presentation discusses the strategy and development [2-7] of a platform that increased the hot-spot energy and hot-spot pressure, to achieve record ICF performance. Radiation hydrodynamic simulations of the plasma conditions will be examined together with observed hot spot properties to illustrate how the thermodynamic tipping point for ignition was achieved on N210808.

[1] J. Nuckolls, et al., Nature, 239, (1972)
[2] O.A. Hurricane, et al., PPCF 61, 014033 (2019); Op Cit., Phys. Plasmas, 26, 052704 (2019)
[3] D.A. Callahan, et al., Phys. Plasmas, 056305 (2018)
[4] A.L. Kritcher, et al., Phys. Rev. E, 98, 053206 (2018)
[5] O.A. Hurricane, et al., Phys. Plasmas, 24, 092706 (2017)
[6] A.B. Zylstra, O.A. Hurricane, et al., in preparation (2021)
[7] A.L. Kritcher, C.V. Young, and H.F. Robey, et al., in preparation (2021)