INTEGRATED MODELING OF NEUTRON DIAGNOSTICS IN ICF

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Neutrons produced by fusion reactions provide some of the key diagnostic tools of the stagnation phase in ICF experiments. The neutrons are born in hot regions of the plasma but interact with other species in both hot and cold regions of the fuel and the ablator, thereby providing a wide variety of diagnostic effects. These diagnostics can be used to measure shape, ion temperature and the ρR of both the DT fuel and ablator material. However, interpreting the data from these diagnostics is challenging due to the inhomogeneous plasma conditions in which the neutrons are produced and interact. The goal of this work is to evaluate the sensitivity of the key signatures from these diagnostics to the conditions of the stagnated plasma. This is achieved by developing computational models of the relevant neutron physics for each diagnostic.

The neutron diagnostics that are studied in this way include primary neutron spectra from both DD and DT reactions, in which the effects of thermal broadening, spectrum shift and broadening due to bulk fluid velocity and attenuation due to scattering are taken into account. A number of signatures in the spectra that could potentially distinguish between broadening due to temperature and broadening due to fluid motion are identified. Secondary neutron spectra, resulting from the elastic scattering of neutrons with deuterons and tritons, are modelled in a consistent manner with the primary spectra. Primary and secondary neutron images are modelled allowing the imaging of both the hot and cold fuel. Finally, gamma ray production from neutron-carbon scattering, and neutron spectra from T+T reactions are modelled. It is shown that the shape of the T+T neutron spectrum is very sensitive to the ion temperature of the plasma.

These synthetic diagnostics are combined into an integrated model of neutron diagnostics that is used in conjunction with the radiation-hydrodynamics code CHIMERA. This code is used to simulate capsule implosions in 3D and data from these simulations is post-processed to produce the synthetic neutron diagnostics output. The integrated neutron model is based on semi-deterministic algorithms that make the production of neutron diagnostics computationally efficient.