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Secondary Nuclear Reactions in Magneto-Inertial Fusion Plasmas*

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The goal of Magneto-Inertial Fusion (MIF) is to relax the extreme pressure requirements of inertial confinement fusion by magnetizing the fuel. Understanding the level of magnetization at stagnation is critical for charting the performance of any MIF concept. We show here that the secondary nuclear reactions in magnetized deuterium plasma can be used to infer the magnetic field-radius product (BR), the critical confinement parameter for MIF [1,2]. The secondary neutron yields and spectra are examined and shown to be extremely sensitive to BR. In particular, embedded magnetic fields are shown to affect profoundly the isotropy of the secondary neutron spectra. Detailed modeling of these spectra along with the ratio of overall secondary to primary neutron yields is used to form the basis of a diagnostic technique used to infer BR at stagnation. Effects of gradients in density, temperature and magnetic field strength are examined, as well as other possible non-uniform fuel configurations. Computational results employing a fully kinetic treatment of charged reaction product transport and Monte Carlo treatment of secondary reactions are compared to results from recent experiments at Sandia National Laboratories' Z machine testing the MAGnetized Liner Inertial Fusion (MagLIF) concept [2]. The technique reveals that the charged reaction products were highly magnetized in these experiments. Implications for eventual ignition-relevant experiments with deuterium-tritium fuel are discussed.

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[1] M.M. Basko et al., Nuclear Fusion, Vol. 40, No. 1 (2000)
[2] S.A. Slutz et al., Phys. Plasmas 17, 056303 (2010)