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The Parameter Space of Magnetized Target Fusion (aka Magneto-Inertial Fusion)

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Magnetized Target Fusion (MTF), aka Magneto-Inertial Fusion (MIF), is an approach to fusion that compresses a preformed, magnetized (but not necessarily magnetically confined) plasma with an imploding liner or pusher. MTF/MIF operates in a density regime in between the eleven orders of magnitude (10^{11}) in density that separate inertial confinement fusion (ICF) from magnetic confinement fusion MCF. Compared to MCF, the higher density, shorter confinement times, and compressional heating as the dominant heating mechanism potentially reduce the impact of magnetic instabilities. Compared to ICF, the magnetically reduced thermal transport and lower density leads to orders-of-magnitude reduction in the difficult-to-achieve areal-density parameter and a significant reduction in required implosion velocity and radial convergence, potentially reducing the deleterious effects of implosion hydrodynamic instabilities. This tutorial presents fundamental analysis [1,2] and simple time-dependent modeling [2] to show where significant fusion gain might be achieved in the intermediate-density regime. The analysis shows that the fusion design space is potentially a continuum between ICF and MCF but practical considerations limit the space in which ignition might be obtained. Generic time-dependent modeling addresses the key physics requirements and defines "ball-park" values needed for target-plasma initial density, temperature, and magnetic field and implosion system size, energy, and velocity. The modeling shows energy gains greater than 30 can potentially be achieved and that high gain may be obtained at low convergence ratios, e.g., less than 15. A non-exhaustive review of past and present MTF/MIF efforts is presented and the renewed interest in MTF/MIF within the US (e.g., ARPA-E's ALPHA program) and abroad is noted.
[1] I. Lindemuth & R. Siemon, "The fundamental parameter space of controlled thermonuclear fusion," Amer. J. Phys. 77, 407 (2009). [2] I. Lindemuth, "The ignition design space of magnetized target fusion," Phys. Plas. 22, 122712 (2015).