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Charged-particle guiding in magnetized cylindrical targets

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The magnetized liner inertial fusion (MagLIF) scheme has been proposed for cylindrical implosions of magnetized fuels with lower implosion velocities and convergence ratios, resulting in an appealing scheme for inertial fusion [1]. Recently, a laser-driven version of MagLIF has been explored at the Omega facility [2] to study the magnetized implosion physics of MagLIF targets scaled down by a factor of 10 in linear dimensions. The advantages of using the Omega laser system are the good illumination symmetry, the higher repetition rate and better diagnostic access. B-field amplifications through flux compression of about 550 have been measured so far in cylindrical and spherical implosions on Omega [3].
Here, we analyze the implosion of a magnetized cylindrical target similar to that used in Omega MagLIF by means of 2-D MHD simulations with the FLASH code [4]. The target is a plastic (CH) hollow cylinder of 2 mm long, 300μm outer radius and 30μm thick filled with a CH foam with the density as a parameter. It is driven by 40 laser beams with a total energy of 15.2 kJ in 1.5 ns. The Omega MagLIF illumination scheme was assumed [2]. Simulations show amplification of the B-field up to 10 kT and higher and magnetic flux conservation around 70% for a foam density of 20 mg/cm3. As such a B-field is high enough to guide fast electrons and even protons, we have conducted 3D hybrid simulations of fast electron and proton transport and energy deposition in the imploded cylindrical target [5,6]. Specifically, we have analyzed if the intense B-fields achieved at target stagnation are able to guide highly diverging laser-driven fast electrons and even the less diverging TNSA protons. The first experimental evidence of fast electron beams guiding by external magnetostatic fields was described in [7]. Here, the B-fields are increased by roughly one order of magnitude due to magnetic flux conservation in cylindrical target implosions. Our study will be useful to determine the conditions of the high energy density matter generated by perfectly collimated electron and ion beams. It may be also relevant for hydrodynamics of magnetized cylindrical targets.
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