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New physics directions for heavy-ion-driven high energy density physics and fusion energy*

B. Grant Logan, LBNL

Abstract

The heavy ion fusion program is shifting research emphasis towards a key scientific question of fundamental importance to both high energy density physics and inertial fusion energy "*How can heavy ion beams be compressed to the high intensities required for creating high energy density matter and fusion ignition conditions"* The primary scientific challenge is to compress intense ion beams in time and space sufficiently to heat targets to the desired temperatures with pulse durations of order or less than the target hydrodynamic expansion time. Recent particle-in-cell simulations of near-term planned experiments of modest scale indicate that intense heavy ion beams inserted with a proper head-to-tail velocity ramp into a long neutralizing background plasma column may be compressed > 100 X in length and focused > 20 X in radius (> 50,000 X increase in intensity). A series of three experiments are being designed to test the physics limits to both longitudinal and radial compression of properly tailored beams in neutralizing plasma with increasing beam current, energy, and pulse compression factors. The first experiment aims for 10X longitudinal compression in plasma by 2006 starting with an existing 25 mA source of 300 kV potassium ions. The second experiment, using a modest upgrade of existing equipment, aims for > 100 X pulse compression of 700 keV helium ions to a peak compressed current of 750 A, (>30J /cm^2 peak in < 1 ns on target). These experiments, if successful, should provide the scientific basis for a new facility in 2015 capable of achieving >10 eV in 0.1 x solid density foam targets, as well as for new heavy ion driver options that support a lower cost modular development path to inertial fusion energy (using multiple separate linacs).

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