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IFE/P6-16: Summary of Progress in U.S. Heavy Ion Fusion Science Research

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Construction of the Neutralized Drift Compression eXperiment (NDCX-II), a new high-current, moderate-kinetic-energy accelerator facility at LBNL, is being completed in the spring of 2012. The machine will produce a nanosecond Li+ ion beam bunch at ˜2 MeV energy for volumetric heating of thin foils. Extensive simulations using the Warp code led to a physics design with specialized acceleration voltage waveforms that can achieve >500-fold longitudinal beam compression. Planned experiments on NDCX-II to study warm dense matter include: measuring equation of state and phase transitions, conductivity, opacity and shock generation. Theoretically, we have: (a) studied transverse and longitudinal beam compression on two-stream interactions of an intense ion beam in plasma; (b) studied transverse gradients and profile shapes on beam-plasma instabilities; (c) identified a class of self-consistent periodic kinetic 'equilibria' for intense beams in alternating-gradient focusing systems, and extended nonlinear perturbative particle simulations to such focusing systems; (d) investigated nonlinear effects of beam-plasma instabilities on beam current neutralization; (e) proposed a Rayleigh-Taylor instability mechanism for droplet formation in expanding warm dense matter; and (f) carried out theoretical studies of using a beam "wobbler"(periodic deflector) as a beam smoothing technique.

Using HYDRA simulations to design the novel Heavy Ion Fusion X-target, it was found that, by adding an aluminum pusher and radial tamping, the fusion gain can be increased from 50 to 300, and the stagnation fuel density doubled to 100 g/cmˆ3 at peak compression, with a "rho-r" ˜2 g/cmˆ2. The X-target has a simple cylindrical metal case filled with DT fuel and a conical insert with an "X"shaped cross-section. Using multiple heavy ion beams to illuminate the target axially from only one side, the fuel can be compressed and ignited at the X-vertex. The simulations showed negligible RT growth leaving a central clean DT ignition zone. We have also developed a directly driven, spherical, tamped, hot-spot ignited target that has high hydrodynamic efficiency while relaxing accelerator phase-space constraints. This target is driven by a combination of an exploding pusher followed by radiation driven ablation.

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