APR08-2008-000352

Abstract for an Invited Paper
for the APR08 Meeting of
the American Physical Society

Energy transport and isochoric heating of ultra-intense laser irradiated target[1]

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Irradiation of matter with ultra-intense short laser pulses generates MeV electrons and can create plasmas at solid density and temperatures of several hundred eV, i.e. several million degrees. Since hydrodynamic expansion of such micrometer-sized targets, driven apart by the Gigabar pressure of MeV hot electrons, limits their lifetime to a few picoseconds, energy must be deposited rapidly, i.e. on a sub-ps time scale, and deep in the target. Therefore, to realize various applications such as a compact neutron source, blight x-ray, and a good test bed of the high energy density physics, it is essential to understand the energy transport inside dense plasmas. We study ultra-fast heating of thin plastic foils by intense laser irradiation theoretically using collisional two-dimensional particle-in-cell simulations. We find that the laser-generated hot electrons are confined laterally by self-generated resistive magnetic fields, heating the laser focal area beyond keV electron temperatures isochorically in a few picoseconds. Also strong surface magnetic fields are excited deu to rapid lateral diffusion of MeV electrons. Using this confinement by the self-generated fields one can excite shock waves that compress the plasma beyond solid density and achieve keV thermal plasmas before the plasma disassembles. Such shocks can be launched at material interfaces inside the target where jumps in the average ionization state and thus electron density lead to Gigabar pressure. They propagate stably over picoseconds accompanied by multi-MegaGauss magnetic fields, and thus have a potential for various applications in high energy density physics.

[1] Work supported by UNR under DOE/NNSA grant DE-FC52-01NV14050 and DOE/OFES DE-FG02-05ER54837.