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# Generation of energetic ions by laser-irradiated plasmas

Alex Arefiev

Institute for Fusion Studies,

The University of Texas at Austin

Austin, Texas 78712, USA

alexey@mail.utexas.edu

The ability to generate copious energetic ions is critical for a number of applications ranging from fusion to proton cancer therapy. One possible way to generate energetic ions is via irradiation of solid targets with intense laser beams. The talk is focused on two distinct targets: a spherical microcluster with the diameter smaller than the laser wavelength and a foil with dimensions greater than the laser wavelength. The significant difference between these two cases is not only the relative target size, but also the laser intensity. The intensity is sub-relativistic in the first case and ultra-relativistic in the second case. We investigate the regimes where the laser field creates a two-component electron distribution with a cold majority and a hot collisionless minority. The hot minority is generated when electrons are accelerated by the laser field at the target surface and then injected back into the target. In the case of a microcluster, the mechanism at work is the Brunel vacuum heating. In the case of a thin foil, there are additional mechanisms that can contribute to electron heating. Specifically, the [jxB] electron heating becomes significant because the laser intensity is ultra-relativistic. In both cases, the electron energy gain at the surface is in the range or below the ponderomotive potential. The hot electrons spread out inside the target. They eventually emerge at the surface and set up a sheath, whose electric field confines them inside the target. The new feature highlighted in the talk is additional stochastic heating experienced by the hot electrons when they re-emerge at the surface of the target irradiated by the laser. Repeated interaction of the electrons with the laser field leads to a gradual electron energy increase, such that eventually the electron energy can significantly exceed the ponderomotive potential. The pressure of the hot electron component forces the target to expand, accelerating ions. This acceleration is caused by an ambipolar electric field generated by the hot electrons. The stochastic heating has been investigated numerically to find the heating rate and the saturation energy. The corresponding results and qualitative estimates for the saturation energy are presented in the talk. The presentation also includes a recently developed first-principle analytical model for an expanding microcluster that describes how the energy absorbed by the electrons from the laser is transferred to the ions. This model treats ion acceleration by the ambipolar electric field and adiabatic cooling of the hot electrons self-consistently. An important result of this model is that the maximum ion energy after the expansion exceeds the cutoff electron energy.