Abstract Submitted
for the DPP10 Meeting of
The American Physical Society

Three-dimensional dynamics of break-out afterburner ion acceleration using high-contrast short-pulse laser and nano-scale targets

L. YIN, B.J. ALBRIGHT, D. JUNG, K.J. BOWERS, J.C. FERNANDEZ, B.M. HEGELICH, Los Alamos National Laboratory — Ultra-intense laser interaction with solid density carbon targets is examined in 3D VPIC simulations. It is shown that a linearly polarized laser pulse at $> 10^{20}$ W/cm^2 intensity will turn a solid density, nm-scale target relativistically transparent and begin an epoch of dramatic acceleration of ions. Called the Break-Out-Afterburner (BOA) [L. Yin, et al., Phys. Plasmas 14, 056706 (2007)], this mechanism leads to order-of-magnitude greater ion energy and beam currents. The BOA lasts until the electron density in the expanding target reduces to the non-relativistic critical density. A striking feature of the BOA mechanism is that the ion beam symmetry is broken, with the production of lobes in the direction orthogonal to the laser polarization and propagation directions, along which the highest ion beam energy is observed. These ion beam lobes have been measured on recent Trident experiments. An analytic theory for the production of ion beam lobes has been obtained and has been shown to be in good agreement with simulations. Moreover, other features of the BOA, e.g., the existence of an optimal target thickness for given laser and target density and the propagation of light and heavy ion species at comparable speed have been demonstrated in simulations and experiments.

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Date submitted: 23 Jul 2010

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