Model of Neutron Production Rates from Femtosecond Laser-Cluster Interactions

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Abstract

Solid deuterium clusters provide a new type of target for laser-matter interactions. We present a theory for the generation of laser driven Coulomb explosions which create a hot fusion-producing ion tail. We derive an initial distribution function for the exploded ions, for an arbitrary cluster size distribution, and solve for the D-D neutron production rate during the free expansion of these ions into a vacuum. We find good agreement between the theory and the experiment: The theory suggests an explanation for the observed saturation and drop in neutron yield beyond a definite cluster size, consistent with recent experiments by Ditmire [T. Ditmire et al., Nature 398, 489 (1999)] and Zweiback [J. Zweiback et al., Phys. Rev. Lett. 84, 2634 (2000); J. Zweiback et al., Phys. Rev. Lett. 85, 3640 (2000)].