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Interaction of intense ultrashort pulse lasers with clusters.[1]

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The last ten years have witnessed an explosion of activity involving the interaction of clusters with intense ultrashort pulse lasers. Atomic or molecular clusters are targets with unique properties, as they are halfway between solid and gases. The intense laser radiation creates hot dense plasma, which can provide a compact source of x-rays and energetic particles. The focus of this investigation is to understand the salient features of energy absorption and Coulomb explosion by clusters. The evolution of clusters is modeled with a relativistic time-dependent 3D Molecular Dynamics (MD) model [1]. The Coulomb interaction between particles is handled by a fast tree algorithm, which allows large number of particles to be used in simulations [2]. The time histories of all particles in a cluster are followed in time and space. The model accounts for ionization-ignition effects (enhancement of the laser field in the vicinity of ions) and a variety of elementary processes for free electrons and charged ions, such as optical field and collisional ionization, outer ionization and electron recapture. The MD model was applied to study small clusters (1-20 nm) irradiated by a high-intensity (10^{16}-10^{20} W/cm^2) sub-picosecond laser pulse. We studied fundamental cluster features such as energy absorption, x-ray emission, particle distribution, average charge per atom, and cluster explosion as a function of initial cluster radius, laser peak intensity and wavelength. Simulations of novel applications, such as table-top nuclear fusion from exploding deuterium clusters [3] and high power synchrotron radiation for biological applications and imaging [4] have been performed. The application for nuclear fusion was motivated by the efficient absorption of laser energy (~100%) and its high conversion efficiency into ion kinetic energy (~50%), resulting in neutron yield of 10^6 neutrons/Joule laser energy. Contributors: J. Davis and A. L. Velikovich. [1] G. M. Petrov, *et al Phys. Plasmas* **12** 063103 (2005); **13** 033106 (2006) [2] G. M. Petrov, J. Davis, *European Phys. J. D* **41** 629 (2007) [3] G. M. Petrov, J. Davis, A. L. Velikovich, *Plasma Phys. Contr. Fusion* **48** 1721 (2006) [4] G. M. Petrov, J. Davis, A. L. Velikovich, *J. Phys.* B 39 4617 (2006)

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