Molecular Dynamics Modeling of Coulomb Clusters in a Quiver Field

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Availability of lasers with ultrashort pulse-durations and relativistic intensities has triggered considerable attention to laser field interaction with small clusters. Test particle studies of electron scattering on ions in an oscillatory electromagnetic field have shown that standard theoretical assumptions of small angle collisions and phase independent orbits are incorrect for electron trajectories with drift velocities smaller than quiver velocity amplitude. This leads to significant enhancement of the electron energy gain and the inverse bremsstrahlung heating rate in strong laser fields. The correlated collisions of electrons being brought back to the same ion by the oscillatory field [1] are responsible for large angle, head-on scattering processes. The statistical importance of these trajectories has been examined for different electron distribution functions. A new scaling of the inverse bremsstrahlung heating rate with drift velocity and laser intensity is discussed. Going beyond the simple test particle studies we have performed molecular-dynamic (MD) simulations of the electron-ion scattering in a presence of a high frequency electric field. The existing MD code [2] was modified to allow simulation of both infinite (periodic) and finite systems of charged particles, including multiple ion species. The code is parallelized on massively parallel platform to model not only small, but also larger systems and clusters [3] with up to million interacting particles. To further speed-up MD calculations we plan to deploy fast tree-code algorithm for N-body problems [4], which showed high efficiency for the vortex simulations [5]. The new heating rates have been parameterized in terms of electron energy, field intensity and plasma parameters such as density and ionization state. Separate study includes simulation of ultra-strong laser field interaction with Coulomb clusters. We investigate peculiarities of the dynamics of clusters Coulomb explosion, and anomalous laser energy absorption by cluster plasma due to correlated collisions.

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