Molecular dynamics simulations of finite-size nonideal plasmas

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Irradiation of solid clusters by a femtosecond laser pulse of moderate intensity (10^{13}-10^{15}W/cm^2) leads to formation of the nonideal plasma with the temperature about a few eV and the nonideality parameter of the order of unity [1]. Due to excitation of the collective electron oscillations in such plasma the resonance absorption is possible for the second femtosecond pulse which follows the first one with a time delay. In particular the experiments [2-3] show that fitting the delay between these two pulses (0.5-10ps for the papers mentioned) allows one to significantly increase the yield of deeply ionized ions and high energy electrons. It was shown experimentally that the optimal delay value depends on the first pulse intensity and on the target matter. Although only the qualitative description of the underlying physical processes is given so far.

In the present work the study of the electron collective oscillations in the ionized Na clusters of 55, 147, and 309 atoms is conducted with the help of molecular dynamics simulations [4]. The distinguishing characteristics of the nonideal plasma for the given cluster sizes (of the order of 1nm) are connected with the strong influence of size effects of dynamical plasma properties, such as the spectrum of electrons oscillations. We report on the frequencies and relative amplitudes of the principal electron oscillations modes and on the spatial structure of these modes. It is shown that the modes detected differ from both the Mie oscillations and the Langmuir plasma waves.

In general the obtained results are concerned with the theoretical study of the finite size nonideal plasmas. At the same time they may be used for further work directed at the enhancement of energy deposition in the laser-cluster interaction.

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