Dynamics of a metal cluster heating and ionization by intense femtosecond laser pulse

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To start calculations below Femi energy of a metal, electron degeneracy is included in the model of collisional heating and impact ionization of a large metal cluster, which radius exceeds skin depth, by intense femtosecond laser pulse [1]. Ionization energy lowering is considered in the frame of hybrid potential model [2], which takes into account strongly and weakly coupled plasma limits. A model of electron recombination is under discussion. Dielectric function is evaluated in the linear and relaxation time approximation. Properly restricted coulomb electron collision frequency along with appropriate choice of coulomb logarithm [3] is used.

It is shown that at the initial stage of cluster heating, when electrons are degenerate, mean ion charge coincides closely with equilibrium one. Ionization equilibrium is violated during the heating with subsequent drop of recombination rate. Ratio of average ion ionization energy to electron temperature shows that ionization is produced by thermal electrons. According to the model, initial iron ion charge equals 3.15 at electron temperature 10 eV. Final electron temperature of iron cluster with radius 25 nm, heated by laser pulse with peak intensity about 10^{18} W/cm^2, FWHM 100 fs and wavelength 1.24 μm, exceeds 3 keV, and average ion charge corresponds to lithium like ions.

1. O.F. Kostenko, N.E. Andreev // Plasma Physics Reports. 2007. V. 33. N 6. P. 503.

2. M.S. Murillo, J.C. Weisheit // Physics Reports. 1998. V. 302. N 1. P. 1.

3. Y.T. Lee, R.M. More // Phys. Fluids. 1984. V. 27. N 5. P. 1273.