Impact of Coulomb collisions on laser-plasma interaction processes at high densities and relativistic intensities

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Nonlinear interaction of laser radiation with a matter at high relativistic intensities when any material medium turns into fully ionized plasma is considered within the Coulomb collisions. At such high densities (in general, solid state) the Coulomb collisions become considerable for electrons acceleration, coherent radiation, as well as nonlinear absorption of strong/superstrong electromagnetic (EM) radiation in the dense plasma. For last process just bremsstrahlung at electron-ion Coulomb collisions is one of the main mechanisms for absorption of plane monochromatic EM radiation by plasma, considered in this work by numerical calculations.

Diverse nonlinear EM processes proceeding in plasma at the interaction with the strong and superstrong laser pulses of ultrashort durations have been systematically studied by us during the last decade. It involves electrons and ions acceleration, electron-positron (e^-,e^+) pair production by high power electron bunches scattering on the plasma ions or at the presence of a second -counterpropagating laser pulse, or e^-,e^+ production by hard gamma-quanta generated under these circumstances in the dense plasma (at the presence of different third bodies necessary for proceeding of each process in plasma), generation of x-ray and gamma-ray coherent radiation by different nonlinear channels, as well as different regimes for absorption laser radiation of ultrarelativistic intensities by dense plasma - towards the implementation of the problem high temperatures plasma (see, e.g. [1]-[3]).

In all these processes it is inevitable Coulomb collisions between the plasma's charged particles, and their impact on the actual values of the mentioned final gains may be significant for considering effects. Furthermore, the absorption process of a plane monochromatic EM radiation in plasma is based just on the bremsstrahlung at electron-ion Coulomb collisions. For this purpose in the current work we have investigated, in general, the impact of Coulomb electron-ion-ion collisions on the interaction dynamics in the dense laser-plasma at relativistic ($\xi \equiv e\mathrm{E}/mc\omega \cong 1$; e, m - are electron charge and mass, respectively, c -is the light speed in vacuum, ω, E - are the laser wave electric field strength and frequency, respectively) and ultrarelativistic ($\xi >> 1$) intensities of laser pulses ultrashort durations.

Investigations have been carried out on the base of analytical calculations in the scope of classical relativistic electrodynamics (nonlinear theory) and numerical simulations for which a special relativistic simulation code has been elaborated. Numerical investigations have been carried out for solid materials with high Z elements (to have high density number of electrons as well), such as Pb, Au, and Pt both for samples of macroscopic scales and nanolayers - relativistic solid plasma targets. The quantitative results of numerical simulations for electrons nonlinear acceleration process and absorption of high intensity laser radiation at the electrons bremsstrahlung on plasma's ions at high and ultrahigh laser intensities show that the contribution of electron-ion-ion Coulomb collisions on the considered effects in the plasma of solid densities is considerable for the mentioned materials as macroscopic scales, as well as for thin (nanoscale) films/relativistic solid-plasma-targets.

References

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