Partial electron degeneracy and moderate plasma coupling effects in ion fast ignition

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Recently some progress was made in a more precise quantification of the moderate plasma coupling and partial electron degeneracy effects in ICF implosions [1,2]. Indeed, during the implosion plasma attains a state where the plasma coupling parameter is no longer small, the commonly used expressions for the Coulomb logarithm becomes invalid and the electron temperature becomes small relative to the Fermi energy. It is of some interest to consider these issues in the context of ion fast ignition. Indeed, for the density of 450 g/cm^3 the Fermi energy is 0.83 keV, so that even for temperatures of the order of 4 keV the effects of partial electron degeneracy may be non-negligible, and for the temperature of 0.1 keV, characteristic for the initial stage of the capsule heating via ion beam, the plasma coupling parameter is of the order of unity. A simplified model is developed, which allows for a speedy evaluation of the improved predictions for the plasma heating. Temporal dependence of the fuel temperature is obtained for a variety of the ion beam and plasma conditions relevant to the ion fast ignition. Under such conditions the electron contribution to the ion stopping power is reduced relative to the standard theory, resulting in an increased ion range. At low temperature and high density the bremsstrahlung losses are inhibited relative to the Spitzer theory, but at the same time the electron thermal conduction rate is higher and the electron-ion equilibration rate is lower, so that the final fuel temperature distribution is sensitive to the fine details of various improvement formulas. These results may be relevant to other phenomena in ICF, such as the diagnostics of the so-called knock-on ions, i.e. fuel ions accelerated through a collision with an energetic neutron.

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References

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