

Effects of an ambient radiation field on charge state distribution of NLTE carbon plasmas

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Synopsis A collisional-radiative model based on detailed level approach is developed to investigate the population kinetics of non-local thermodynamic equilibrium (NLTE) carbon plasmas. Present model is used to diagnose a recent measurement for average ionization degree of carbon plasmas at 0.2 g/cm³ [G. Gregori *et al.*, Phys. Rev. Lett. **101**, 045003 (2008)]. Physical factors which may influence the population kinetics are investigated in detail and it indicates that the high temperature radiative field plays an important role on the ionization balance.

Radiative opacity of hot dense plasmas remains a subject of current interest since it has important applications in the research of inertial confinement fusion (ICF) and stellar physics. In many ICF experiments, LTE was usually not satisfied and therefore one must assume non-LTE (NLTE) condition. Recently, Gregori *et al.* [1] used spectrally and time-resolved X-ray scattering to extract the temperature and charge state evolution in a near solid density (0.2 g/cm³) carbon foam driven by a supersonic soft X-ray heat wave. The results showed that there is a large difference between the experiment and theoretical models, especially at low temperature.

In the present CR model, level populations are calculated by solving steady-state rate equations [2, 3, 4]. In the steady-state assumption, the populations of the levels are constant, due to the exact balance between the various populating and depopulating atomic processes. For each level i , the rate equation can be written as

$$\frac{dn_i}{dt} = \sum_{j \neq i}^{N_L} n_j R_{ji} - \sum_{j \neq i}^{N_L} n_i R_{ij}, \quad (1)$$

where n_i is the population of level i and R_{ij} and R_{ji} represent the depopulating and populating rates for levels i , and N_L is the total number of levels included in the rate equation.

The measured electron temperature T_e are 40, 50, 60, 70, 90 and 130 eV, respectively and the corresponding temperature of the radiative field T_r are 196.25, 220, 217.5, 230, 255 and 272.5 eV, respectively [1]. Fig.1 shows the average ionization degree of the experiment and theoretical works. In panel (b), present results at $T_r=0$ and $T_r = T_e$ are shown for comparison. It can clearly

be seen that the experimental carbon plasmas are not in LTE due to the high-temperature radiative field.

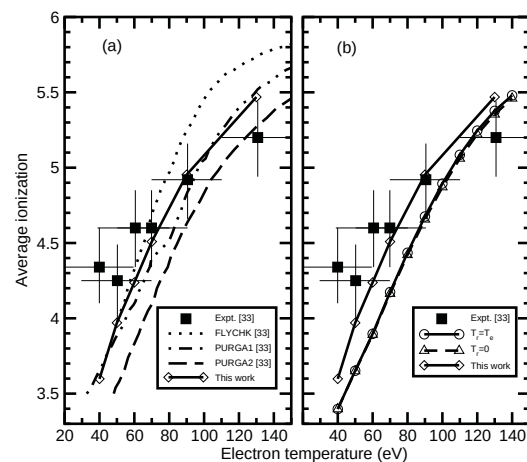


Figure 1. Average ionization as a function of temperature for carbon plasmas at mass density of 0.2 g/cm³. The experimental and other theoretical results are from ref. [1]. In panel (b), present results at $T_r=0$ and $T_r = T_e$ are shown.

References

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