The Difference between the Ionization Equilibria of Hydrogen-like and Alkali-like Impurity Ions in Optically Thin Plasmas

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There are many plasmas in which the populations of the various energy states of ions and electrons assume a steady state, but complete local thermal equilibrium is prevented because, on the one hand, radiation absorption is absent and, on the other, the electron density is too low. This often applies to impurity ions which are added to a high temperature hydrogen plasma.

Where hydrogen-like ions are involved it is in order to dispense with detailed calculations and describe the ionization equilibrium with the corona formula, which is obtained essentially by equating the collision ionization processes from the ground state with the radiative recombination processes to the ground state.

In the case of other ions, however, neglecting the excited states may result in serious errors. This is because the corresponding terms - unlike those for hydrogen-like ions, which are relatively near the ionization limit - are distributed much more uniformly between the ground state and ionization limit. The implications of this behaviour are discussed with reference to alkali-like ions. A model for the term systems and the collision and radiation coefficients is used to derive quantitative results. These may be expressed by approximation formulae which probably describe the ionization equilibrium better than the corona formula. According to these the ratio of the densities of the lithium-like O VI ions and the next higher level of ions (O VII), for instance, may differ (for electron densities $n_e = 5 \times 10^{17}$ cm^{-3}) from the result of the corona formula by a factor of 20.

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