§12. Collisional-Radiative Model including Dielectronic Excited States

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Dielectronic recombination is a process ofdielectronic capture into a doubly excited state following radiative stabilization from a doubly excited state to a singly excited state. The dielectronic recombination rates are determined by the radiative decay rate and autoionization rate from the doubly excited states. A doubly excited state produced by dielectronic capture is called a dielectronic state.

At high density, however, excitation by electron impact from doubly excited states occur more rapidly than radiative transition. A series of excitation processes leading to ionization is called ladder-like ionization. The process of ladder-like excitation-ionization after dielectronic capture is called dielectronic capture-ladder like (DL) excitation-ionization. DL excitation-ionization is an additional process to direct excitation, increasing effective excitation and ionization rate coefficients for increasing density.

For 1s-2s excitation, besides the direct excitation (1s+e -> 2s+e), DL excitation-ionization, 1s+e -> 2snl+e -> 2sn'l'+e -> 2sn''l''+e -> ...2s+e (n', n'' > n, l', l''> l), becomes effective at high densities. For 1s-2p excitation, DL excitation-ionization, 1s+e -> 2pnl+e -> 2pn'l'+e -> 2pn''l''+e -> ... 2p +e, also becomes important. At the same time, the radiative transition 2pnl-1snl, which is faster than the 2pnl-2pn'l'(n'= n-1, l'=l-1) transition, emits satellite lines. DL collsional processes change the intensities of the satellite lines.

In this paper, we were studied the effect of density on the excitation rate coefficients for 1s-2s and 1s-2p transitions of H-like ions, by constructing a collisional-radiative (CR) model including dielectronic states 2snl and 2pnl of He-like ions.

Previously CR models including dielectronic excited states were constructed for 2snl and 2pnl separately, for quasi-steady plasma, in order to calculate effective excitation and ionization rate coefficients at high densities[1]. These CR models include atomic processes of excitation/de-excitation, ionization/three body recombination, radiative recombination by electron impact, radiative transition, autoionization, and dielectronic capture. Rate coefficient of inverse processes were calculated using detailed balance. Photoionization was not included assuming an optically thin plasma.

In order to study density dependence of effective excitation rate coefficient in more detail, we combined CR models of 2snl and 2pnl together. The collisional transitions between 2snl-2pnl by electron impact are added in our CR model. The excitations for 2snl-2pn'l'(n'≠ n, l'≠ l) are neglected, because the excitation rates for these transitions are predicted smaller than those for 2snl-2pnl transitions. We studied collisional effect of 2snl-2pnl transitions on the effective excitation rate coefficients.

Fig. 1 shows the DL excitation rate coefficients as a function of electron density for 1s-2s and 1s-2p of H-like Ne ions at electron temperature of 2.32×10^6 K. Effective excitation rate coefficient increases for increasing electron density. Contribution of 2snl-2pnl collisions appears at around $N_e > 10^{19}$cm^{-3}. The collisional processes between 2snl and 2pnl increase the effective excitation rate coefficient for 1s-2s and decrease that for 1s-2p, respectively. These effects disappear for $N_e > 10^{23}$cm^{-3}, because the population densities reach near local thermodynamic equilibrium.

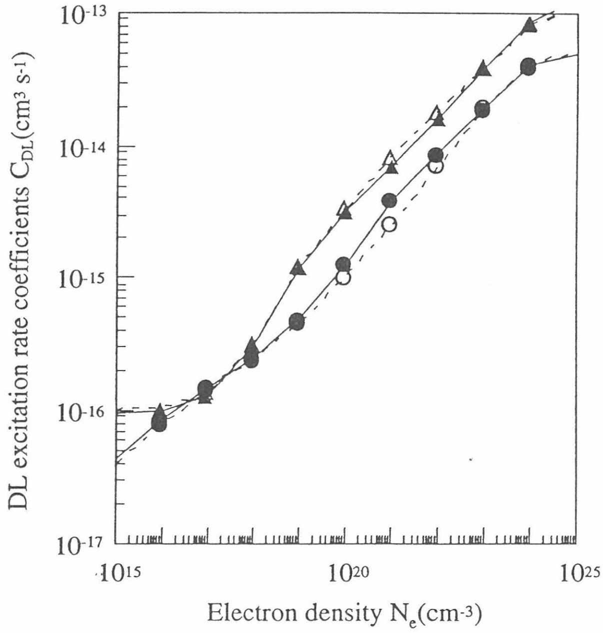

Fig. 1 DL excitation rate coefficients for 1s-2s and 1s-2p of H-like Ne. Open-circle and closed circle is for 1s-2s and 1s-2p, respectively. Solid line and dashed line is with 2snl-2pnl collisional transition and without, respectively.

Reference

[1] T. Fujimoto and T. Kato, Phys. Rev. Lett. 48, 1022 (1982), Phys. Rev. A32 1663 (1985), Phys. Rev. A35 3024 (1987)