§1. Dielectronic Recombination into Mg-like Ions

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Dielectronic recombination (DR) is one of the important processes governing ionization state of ions in various plasmas and a lot of theoretical and experimental studies on DR have been done for K-shell and L-shell ions, but a few for M-shell ions. Recently Netzer[1] and Kraemer et al.[2] suggested importance of M-shell Fe ions for astrophysical plasmas. The solar observational satellite HINODE measures the sun EUV spectra of Fe M-shell ions with on-board EUV Imaging Spectrometer (EIS)[3] and also we measured EUV spectra of LHD plasmas with the same spectral region of the EIS[4]. Reliable atomic data are necessary to analyze the spectra and to examine the plasma conditions.

We focus on the DR processes forming Mg-like ions. The DR rate coefficients are calculated for Mg-like iron (Fe^{14+}) , Zinc (Zn^{18+}), Krypton (Kr^{24+}) and Molybdenum (Mo^{30+}) ions[5]. The DR processes,

$$A^{q+}(1s^22s^22p^63s) + e$$
$$\rightarrow A^{(q-1)+}(1s^22s^22p^6(3l'nl,4l'nl), 1s^22s^22p^53l''3l'nl)$$
$$\rightarrow A^{(q-1)+}(1s^22s^22p^6(3l'nl,4l'nl))$$

are considered. In order to obtain the DR rate coefficients, we calculated energy levels, radiative transition probabilities, and autoionization rates for $2p^63l'nl$ (n =3-n_1, l<8, with n_1=12-14), $2p^64l'nl$ (n =4-7, l<n), and $2p^53l''3l'nl$ (n =3-4, l<n) states in Fe^{14+}, Zn^{18+}, Kr^{24+} and Mo^{30+} ions by using the Hartree-Fock-Relativistic method (Cowan code [6,7]).

Autoionizing states are the $2p^63pn_2l$ states with $n_2 \geqslant 10$ (Fe^{14+}), 11 (Zn^{18+}), or 12 (Kr^{24+} and Mo^{30+}) and the $2p^63dn_3l$ states with $n_3 \geqslant 7$ (Fe^{14+} and Zn^{18+}), 8 (Kr^{24+}), or 9 (Mo^{30+}). Some of the $2p^64l'4l$ states are located below the first 3s threshold and are not autoionizing. All $2p^64l'nl$ states with n = 4-7 are below the third 3d threshold for these ions.

The state-selective and total DR rate coefficients are derived as a function of electron temperature, as shown in Figs. 1 and 2 as examples. The contribution of high n levels is taken into account with $1/n^3$ scaling law for autoionizing rates and transition probabilities up to n=1000. The behavior of the DR rates at low temperatures, T_e <1eV, strongly depends on the energy level structure near the 3s threshold. Configuration mixing also plays an important role for the DR rate coefficients of 3snl states with low n at low temperatures. The DR processes by 2p-nl transitions through $2p^53l''n'l'nl$ states become important at T_e>200eV. Total DR rate coefficients are in good agreement with previously published data[8,9,10].

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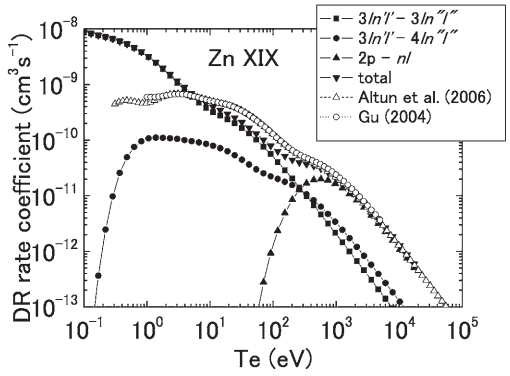

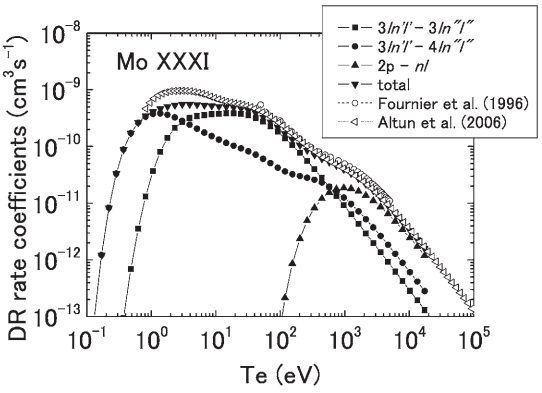

Fig. 1. Total DR rate coefficients for Mg-like Zn and Mo as a function of electron temperature.

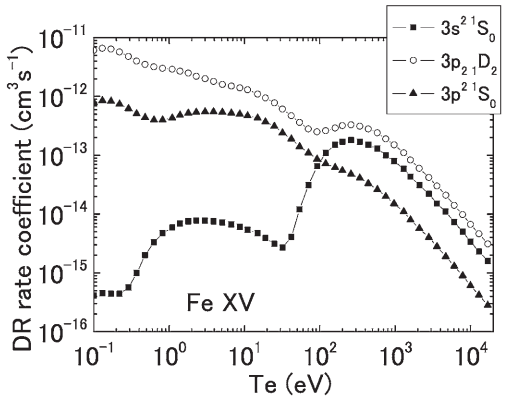

Fig. 2. State selective DR rate coefficients for 3l3l' states of Mg-like Fe as a function of electron temperature.