§14. Dielectronic Recombination Rate Coefficients to Excited States of Mg-like Fe and Dielectronic Satellite Lines

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Energy levels, radiative transition probabilities, and autoionization rates for Mg-like Fe (Fe^{14+}) including $1s^2$ $2s^2$ $2p^6$ $3l'nl$, and $1s^2$ $2s^22p^6$ $4l'nl$ (n= 3-12, $l \le n-1$) states are calculated by the Hartree-Fock-Relativistic method (Cowan code). Autoionizing levels above the thresholds $1s^2$ $2s^2$ $2p^6$ $3l$ (l=s, p, d) are considered. Configuration mixing [3s*n*s + 3d*n*d], [3s*n*p + 3p*n*s + 3p*n*d + 3d*n*p] plays an important role for all atomic characteristics. Branching ratios relative to the first threshold and intensity factors are calculated for satellite lines, and dielectronic recombination (DR) rate coefficients are obtained for the excited 444 odd-parity and 419 even-parity states. It is found that the contribution of the highly excited states is very important for the DR rates. The contributions from the excited $1s^22s^22p^63l'nl$ states with $n \ge 12$ and $1s^22s^22p^64l'nl$ states with $n \ge 7$ to the DR rate coefficients are estimated by extrapolation of all atomic characteristics. The total DR rate coefficient is derived as a function of electron temperature. The state-selective DR rate coefficients to excited states of Mg-like Fe, which are useful for modeling Fe XV spectral lines in a recombining plasma, are calculated as well [1)].

Dielectronic recombination from Fe^{15+} to the excited states of Fe^{14+} is defined by the following sequence of processes:

Fe^{15+} (3s) + e ----> Fe^{14+} ($3pn_1l_1 + 3dn_2l_2 + 4ln_3l_3$)
---> Fe^{14+}($3snl'_1 + 3pnl'_2 + 3dnl'_3$) + $h\nu$.

As the initial state we consider the ground state of Fe^{15+}, 3s. The doubly excited states, $3pn_1l_1$ ($n_1 \ge 10$), $3dn_2l_2$ ($n_2 \ge 7$), and $4ln_3l_3$ ($n_3 \ge 4$), are taken into account as autoionizing intermediate states.

The DR rate coefficients $\alpha(j, i_0)$ to the excited state of Fe^{15+} are obtained by summing up the intensity factor Q_d (j, i, i_0) multiplied by the exponential factor, over the autoionizing levels *i* as follows:

$$\alpha_d(j,i_0) = 3.3\times10^{-24}\left(\frac{I_H}{T_e}\right)^{3/2}\sum_i e^{-\frac{Es_i}{Te}}Q_d(j,i,i_0)/g(i_0)$$

where

$$Q_d(j,i,i_0) = g_iA_r(i,j)K(i,i_0),$$

$$K(i,i_0) = \frac{A_a(i,i_0)}{A_r(i)+A_a(i)},$$

$$A_r(i) = \sum_k A_r(k,i), \text{ and}$$

$$A_a(i) = \sum_{i0'} A_a(i,i_0')\cdot$$

Here $A_r(k, i)$ are radiative transition probabilities, $A_a(i, i_0)$ are autoionization rates, and $Es(i)$ is the level energy of autoionizing level *i* measured from the first ionization threshold.

The total DR rate coefficient is obtained by the summation of the rate coefficients of DR processes through all possible intermediate states (Fig.1). Our results are compared with the result by Gu (2004) [2)] and agree well for 10eV < T_e < 100eV. The disagreement at high T_e could be explained by the inner-shell excitation of a 2*l* electron. We could not comment on the disagreement at low T_e since Gu gave the DR rate only at T_e > 1 eV.

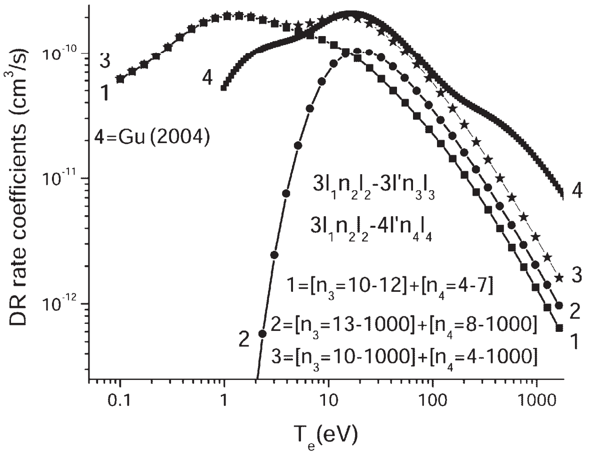

Fig.1 Total DR rate coefficient as a function of electron temperature (no. 3), compared with rate coefficient obtained by Gu [2)] (no.4). Line with no. 2 is the sum of the contributions from highly excited intermediate states.

References
1) I. Murakami et al, J. Phys. B, **39** (2006) 2917.
2) M. F. Gu, ApJ. Suppl., **153** (2004) 389.