§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.\(^3\) 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\(^3\). 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,

\[ \text{A}^{\text{g}(1)} (1s^2\text{2s}^2\text{2p}^6) + e \rightarrow \text{A}^{\text{g}(1)} (1s^2\text{2s}^2\text{2p}^6 (3l'nl'), 1s^2\text{2s}^2\text{2p}^5 \text{3l'}3l'nl) \rightarrow \text{A}^{\text{g}(1)} (1s^2\text{2s}^2\text{2p}^6 (3l'nl',4l'nl)) \]

are considered. In order to obtain the DR rate coefficients, we calculated energy levels, radiative transition probabilities, and autoionization rates for \(2p^53l'nl\) (\(n=3-n_1, l<8\), with \(n_1=12-14\)), \(2p^44l'nl\) (\(n=4, l<6\)), and \(2p^53l'3l'nl\) (\(n=3-l_n\)) 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 \(2p^52pnl\) states with \(n_2 \geq 10\) (Fe\(^{14+}\), 11 (Zn\(^{18+}\)), or 12 (Kr\(^{24+}\) and Mo\(^{30+}\)) and the \(2p^43dnl\) states with \(n_3 \geq 7\) (Fe\(^{14+}\) and Zn\(^{18+}\), 8 (Kr\(^{24+}\)), or 9 (Mo\(^{30+}\)). Some of the \(2p^44l'nl\) states are located below the first 3s threshold and are not autoionizing. All \(2p^44l'nl\) 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, \(T_e <1\) eV, 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 \(2p^53l''nl\) states become important at \(T_e>200\) eV. Total DR rate coefficients are in good agreement with previously published data\(^8,9,10\).