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Multipole rate coefficients for excitation of Fe XIII by isotropic Maxwellian electrons

A. F. Sekkal-Haddouche, M. K. Inal, and M. Benmouna

Department of Physics, Faculty of Sciences, University of Tlemcen, 13000 Tlemcen, Algeria

Knowledge of the usual rate coefficients for electron-impact excitation of ions between fine-structure levels may not be sufficient to interpret line emission from plasmas even with an isotropic Maxwellian electron distribution. This is particulary true when the line emission is due both to collisions with isotropic electrons and photoexcitation by anisotropic radiation coming from an external source [1], as it occurs, for example, in the solar corona under irradiation by the photosphere. For the analysis of line emission from plasmas under those conditions, the multipole rate coefficients C^K for excitation by isotropic electrons are needed. The possible values of the quantum number K are $0, \ldots, 2\min(J_i, J_f)$, J_i and J_f being the total angular momenta of initial and final levels involved in the excitation. The calculation of C^K requires integration over an energy electron distribution of the multipole collision strength Ω^K given by [2]

$$\Omega^K = \sum_\lambda (-1)^{J_i+J_f+K+\lambda} \begin{Bmatrix} J_i & J_i & K \\ J_f & J_f & \lambda \end{Bmatrix} \Omega_\lambda, \quad (1)$$

where $\{\}$ denotes a $6j$ symbol and Ω_λ is the λ component of the usual collision strength Ω, i.e., $\Omega = \sum_\lambda \Omega_\lambda$, λ being the multipole order of the Coulomb interaction between electrons.

Assuming a Maxwellian distribution for the electrons, we have calculated the C^K for transitions in the Si-like Fe XIII ion between levels of the $3s^2 3p^2$ ground configuration and from $3s^2 3p^2$ to $3s^2 3p3d$ levels for temperatures T_e in the range $(0.7-5)\times10^6$ K. These transitions are of interest in solar corona diagnostics based on the infrared magnetic-dipole lines $3p^2\,{}^3P_1 \rightarrow 3p^2\,{}^3P_0$ and $3p^2\,{}^3P_2 \rightarrow 3p^2\,{}^3P_1$ and extreme ultraviolet optically-allowed lines $3p3d\,{}^3P_1 \rightarrow 3p^2\,{}^3P_0$ and $3p3d\,{}^3D_{2,3} \rightarrow 3p^2\,{}^3P_2$. Computations of Ω^K have been carried out at several scattered-electron energies from 0.01 eV up to 2 keV, using a modified version [2, 3] of the relativistic distorted-wave program of the Flexible Atomic Code [4]. Configuration interactions among $3s^2 3p^2$, $3s3p^3$, $3s^2 3p3d$, $3p^4$, $3s3p^2 3d$ and $3s^2 3d^2$ configurations were included in the computations.

As an example, we give in figure 1 the results for the transitions $3p^2\,{}^3P_2 \rightarrow 3p3d\,{}^3P_1$, $3p^2\,{}^3P_1 \rightarrow 3p3d\,{}^3D_2$, and $3p^2\,{}^3P_2 \rightarrow 3p3d\,{}^3D_3$ including all the contributing λ-terms in the summation of equation (1). It is seen that the curves C^K versus T_e are nearly parallel exhibiting a broad peak at practically the same temperature about 2×10^6 K. If one takes into account only the dominant $\lambda = 1$ term, one finds that $C^{K\neq0}$ increases very slightly, by less than 3% for the three transitions. This is consistent with the quasi-parallel trends of the C^K curves observed in figure 1 for each transition, considering the fact that $C^{K\neq0}$ is proportional to C^0.

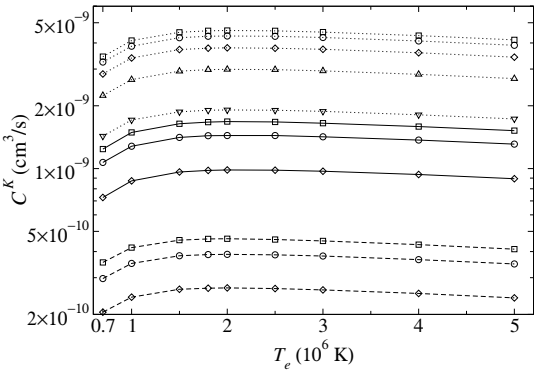

Figure 1: C^K ($K=0-2$) for $3p^2\,{}^3P_2 \rightarrow 3p3d\,{}^3P_1$ (solid curves) and $3p^2\,{}^3P_1 \rightarrow 3p3d\,{}^3D_2$ (dashed curves), and C^K ($K=0-4$) for $3p^2\,{}^3P_2 \rightarrow 3p3d\,{}^3D_3$ (dotted curves). □: C^0, ○: C^1, ◇: C^2, △: C^3, ▽: C^4.

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