§8. Transitions between Fine-structure Levels of *FeXX* Ion in Collisions with Protons in High-temperature Plasmas

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Since the pioneer work of Seaton [1] it is a common knowledge fact that collisions of ions, including multicharged ions, with protons may play important role for the energetic level populations, the radiation emission and the energetic balance in high temperature astrophysical and laboratory plasmas. In the case of multicharged ions at temperatures typical for Solar corona or laboratory plasmas the contribution of proton collisions may be comparable with the contribution of electron collisions mainly for transition between fine-structure levels.

Looking through the list of references of the review[2] it is easy to see that the ion $FeXX = Fe^{19+}$ is a kind of exception among other Fe ions. Only one set of computational results on proton excitation rates was published rather long ago for this ion [3]. These results were obtained in the well known semiclassical approximation for collisions with the inclusion of the Coulomb interaction of partners [4], that is in the first approximation of the perturbation theory in the frames of impact parametre method with the Coulomb trajectories of the nuclei of the partner ions and with quadrupole potential of interaction having a singularity at small internuclear distance.

Proton-impact excitation cross sections and excitation rate cofficients for transitions among all the ground state fine-structure levels of Fe XX ion $1s^2 2s^2 2p^3$ ($^4S_{3/2}$,$^2D_{3/2}$,$^2D_{5/2}$,$^2P_{1/2}$,$^2P_{3/2}$) were computed. The close-coupling approximation of the impact-parametre method with the Coulomb trajectories of the relative motion of nuclei was used. All the m-components of the initial and final target states were taken into account. The interaction matrix elements between target states were calculated numerically for every step of integration with the wave functions of $2p^3$ electronic configuration written in the intermediate coupling scheme with the numerical semi-empirical one-electron functions [5]. The size of the time step in the integration scheme and the interval of the time integration were chosen authomatically for every value of the impact parametre to guarantee the integration accuracy better than 2%. The accuracy of the numerical computation of the impact parametre integral for the total cross section was better than 1%. The excitation rate cofficients were calculated for the temperature range 3×10^6 - 6×10^8K and compared with the only available results of semiclassical approximation (first perturbative approximation of the impact parametre method) [3] in the temperature range 6×10^6 - 1.5×10^7K. The calculated close coupling values of the excitation rate cofficients are found to be somewhat smaller than the semiclassical results [3] in the temperature overlapping interval (Fig. 1). The main results of our computations for the excitation rate cofficients are presented in Table 1.

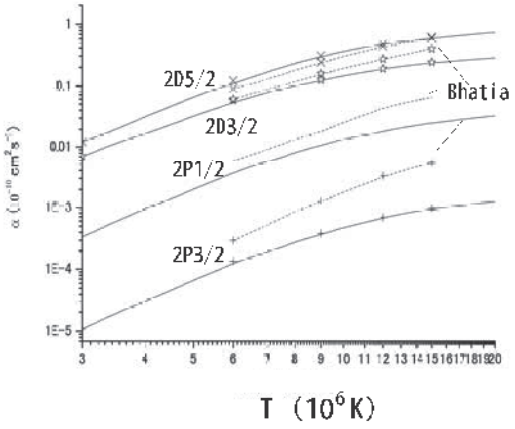

Fig. 1: The proton impact excitation rate coefficients for the $^4S_{3/2}$ - ^2L_J transitions. Present results (solid lines) and results by Bhatia and Mason [3] (dashed lines).

Table I: The excitation rate cofficients, $cm^3 s^{-1}$; the standard abbreviation $7.1 \times 10^{-3} \equiv 7.1 - 3$ is used.

T, 10^6 K	3	6	9	12	15	60
$^4S_{3/2} - ^2D_{3/2}$	7.1-3	5.8-2	0.13	0.19	0.24	0.37
$^4S_{3/2} - ^2D_{5/2}$	1.2-2	0.12	0.30	0.48	0.63	1.06
$^4S_{3/2} - ^2P_{1/2}$	3.4-4	4.0-3	1.1-2	1.9-2	2.6-2	5.2-2
$^4S_{3/2} - ^2P_{3/2}$	1.1-5	1.3-4	3.9-4	6.8-4	9.7-4	2.1-3
$^2D_{3/2} - ^2D_{5/2}$	0.13	0.34	0.53	0.66	0.743	0.82
$^2D_{3/2} - ^2P_{1/2}$	0.11	0.44	0.81	1.11	1.35	1.93
$^2D_{3/2} - ^2P_{3/2}$	9.8-3	0.10	0.25	0.40	0.52	0.88
$^2D_{5/2} - ^2P_{1/2}$	8.3-2	0.32	0.63	0.90	1.10	1.59
$^2D_{5/2} - ^2P_{3/2}$	8.3-2	0.37	0.76	1.09	1.34	1.76
$^2P_{1/2} - ^2P_{3/2}$	0.15	0.35	0.56	0.71	0.82	0.96

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3) Bhatia, A. K. and Mason, H. E. (1980) *Astron. Astrophys.*, **83**, 380.

4) Alder, K., Bohr, A., Huus, T., Mottleson, B. and Winther, A. (1956) *Rev. Mod. Phys.*, **28**, 432. ion with Coulomb intrasction for nucl. coll.

5) Shevelko, V. P. and Vainshtein, L. A. (1993) *Atomic Physics for Hot Plasmas*, Bristol: IOP Publ.