§ 6. Comparison of Atomic Data on Autoionizing States of He-like Mg Ions

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From high temperature plasma, Lyman α lines and associated satellite lines have been observed [1,2]. In order to interpret the observed spectra, atomic data are very important. In this report, we compare with the three different theoretical data calculated using i) MZ code by Safronova (MZ) [3,4], ii) a code based on relativistic many-body perturbation theory combined with complex rotation by Lindroth (MBL)[5] and iii) a code based on relativistic many-body perturbation theory by Safronova (MBS)[6].

We compare the atomic data for satellite lines 1s2*l* – 2*l*'2*l*, 1s3*l* – 2*l*'3*l*, 1s4*l* – 2*l*'4*l*, and 1s5*l* – 2*l*'5*l*. Three atomic data sets by MZ, MBS, and MBL are compared with wavelengths, radiative transitions, autoionization rates, and intensity factor Q_d,

$$Q_d = \frac{g_i A^r_{i,j} A^a_i}{\sum_j A^r_{i,j} + \sum A^a_i}, \tag{1}$$

where g_i is a statistical weight for upper state *i*, A^r is a radiative transition rate from level *i* to *j*, A^a is an autoionization rate from level *i*. The data by MZ are represented by LS coupling and those by MBS and MBL by jj coupling scheme. Generally for 2*l*2*l*' and 2*l*3*l*' lines, agreements are good. Large differences are found for 2*l*4*l*' and 2*l*5*l*' lines between MZ and many body theory (MBS and MBL). In the following, the difference of atomic data are represented by percentage which are one hundred times of MBS/MZ – 1 and MBL/MZ – 1, respectively.

Convoluted intensity factor Q_d calculated using different atomic data, MZ, MBS and MBL, are compared in Fig.1 for (a) n = 2, (b) n = 3, (c) n = 4 and (d) n = 5 transitions in a form of $Q_d \times P(\lambda)$ where $P(\lambda)$ is Voigt profile as a line profile.

Most of the data for 1s2*l* – 2*l*'2*l* transitions, the Aa and Ar values agree within ±20%. The difference in intensity factor Q_d for these transitions are about 10%. The largest difference for A^a value is 30% for the $2p^2\ {}^3P_2$ state which is the upper state of line d. The disagreement in Q_d for d line ($2p^2\ {}^3P_1$ – $1s2p\ {}^3P_1$) is also 30% for both MBS and MBL data. For J line ($1s2p\ {}^1P_1$ – $2p^2\ {}^1D_2$) which has the largest A^a in satellite lines, wavelength of MBS is 1.6mÅ shorter than MZ and MBL.

The difference for 1s3*l* – 2*l*'3*l* transitions are larger than those for 1s2*l* – 2*l*'2*l* transitions. The differences of A^a for $2p3d\ {}^1F_3$, the upper level of line f, are 40% for MBS and 5% for MBL, and the differences of Q_d are 13% for MBS and –7% for MBL, respectively. In the wavelength range of 8.43 – 8.44Å, there are three main lines, $1s3p\ {}^3P_2$ – $2p3p\ {}^1D_2$, $2s3d\ {}^3D_2$, and $2p3p\ {}^3P_2$, by MZ representation. Three lines have two Q_d with 1 – 2 × $10^{13}s^{-1}$ and one Q_d with order of $10^{11}s^{-1}$. We find the difference between MZ and MBS for Q_d values for three lines. Probably this difference is due to the identification of the lines by different LS and jj scheme. As shown in Fig. 1(b) the spectrum is not different with three models. The spectrum in 8.44 – 8.46Å consists of relatively strong several lines. These lines also have disagreement by the difference of correspondence. However the convoluted spectrum agrees well each other. The strongest line in this wavelength range is $1s3d\ {}^3D_3$ – $2p3d\ {}^3F_2$ and the atomic data for this transition agree well.

Data for 1s4*l* – 2*l*'4*l* transitions have much larger discrepancy than those for n = 2 and 3. Especially, A^a values by MZ for $2p4f\ {}^3D_{1,2,3}$, which are the upper states of satellite lines in the wavelength range of 8.4157 – 8.4158Å are larger by 1 – 4 order of magnitude than those by MBS and MBL. Therefore, Q_d values of these transitions by MZ are also larger by 1 – 3 order of magnitude than MBS and MBL.

For n = 5 transitions, Q_d values of transitions from the upper states $2s5f\ {}^3F$ and $2p5f\ {}^3D$ by MBL are smaller by 1 – 3 order of the magnitude than those by MZ, because the autoionization rate by MBL is smaller than MZ by 2 – 4 order of the magnitude. Therefore the large difference is found at around 8.417Å as shown in Fig. 1(d). The Q_d value for $1s5d\ {}^3D_3$ – $2p5d\ {}^3F_4$ (8.426Å) transition by MBL is 20% of that by MZ since the autoionization rate is about 20% and the radiative transition rate is 30% of those by MZ.

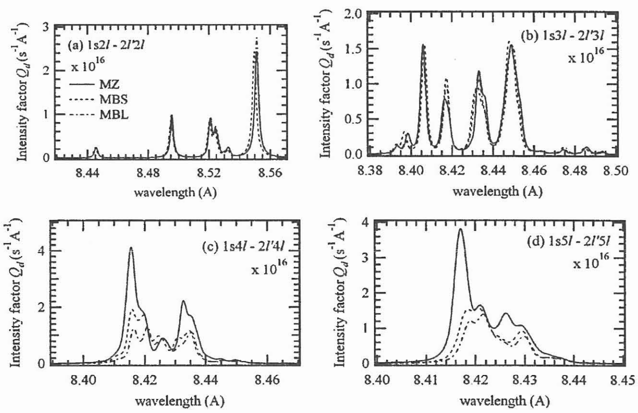

Figure 1. Comparison of intensity factor convoluted by a voigt profile function by MZ (solid line), MBS (dotted line), and MBL (dot-dashed line), respectively. Ion temperature T_i = 200eV and instrumental width 1.5mÅ are assumed. (a) 1s2*l* – 2*l*'2*l*, (b) 1s3*l* – 2*l*'3*l*, (c) 1s4*l* – 2*l*'4*l* and (d) 1s5*l* – 2*l*'5*l* transitions.

References

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