§17. OV Spectral Lines in Ionizing Plasma and Recombining Plasma

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OV spectral lines are often used for diagnosing laboratory plasmas and astronomical plasmas. OV resonance line at 630 Å is used for monitering plasma in the LHD and some OV lines are measuered with VUV spectroscopy for LHD plasmas. Kato, Lang, and Berrington (1990) [1] evaluated excitation rate coefficients of Be-like oxygen and calculated spectral line intensities with a collisional-radiative model. Measurement of OV triplet lines for $2s3s\ ^3S_1$-$2s3p\ ^3P_J$ transitions in laboratory plasma was presented by Kato *et al.* (1996) [2] and they compared the line ratios with calculations based on the model of Ref. [1]. However, the calculation did not reproduce the measured ratio well with plausible plasma conditions.

On the other side, we measure recombining plasmas in the later phase of LHD plasma. We need a model for OV spectral intensities which can be applied also for a recombining plasma.

In order to solve these problems, we have constructed a collisional-radiative model (CRM) for Be-like oxygen, including recombination processes, and here compare calculated line ratios with the experiments of Ref. [2].

Our CRM assumes a steady state for population densities of excited states of O^{4+} ion when solving rate equations. By the CRM a population density of excited state i can be expressed as $n(i) = N_I(i)n_1 + N_R(i)n_+$ where n_1 is the O^{4+} ground state density and n_+ is the O^{5+} ground state density. The former term is ionizing plasma component and the latter recombining plasma component. We take into account excited states up to $n = 50$ for $2snl$ states and $2pnl$ with $n < 7$. The autoionizing states $2pnl$ with $n \geq 7$ are not included in our CRM. We include excitation/de-excitation, ionization, recombination and radiative processes. In order to include the dielectronic recombination, we have calculated dielectronic recombination rate coefficients for excited states [3] with Cowan's code [4].

Figure 1 shows the line intensity ratio of the OV triplet lines for $2s3s\ ^3S_1$-$2s3p\ ^3P_J$ transitions with the measurement from Ref.[2]. The measured ratio is plotted at $n_e = 10^{14}\mathrm{cm}^{-3}$ and $T_e = 100$eV which are indicated in Ref.[2]. Our model can reproduce the measurement and indicates $30eV \lesssim T_e \lesssim 300$eV and $10^{13}\mathrm{cm}^{-3} \lesssim n_e \lesssim 10^{15}\mathrm{cm}^{-3}$ as plasma condition. The difference from Ref.[2] comes from the cascade effect from upper excited states, which is neglected in Ref.[2]. Collisional excitation to higher excited states affect population densities of lower states by radiative cascade. The line ratios of these triplet lines in recombinig plasma do not show big difference from ones of ionizing plasma, since the population densities of the upper level $2s3p\ ^3P_J$ are mainly dominated by collisional processes from the metastable state 2s2p ^{3}P for the density region of laboratory plasmas.

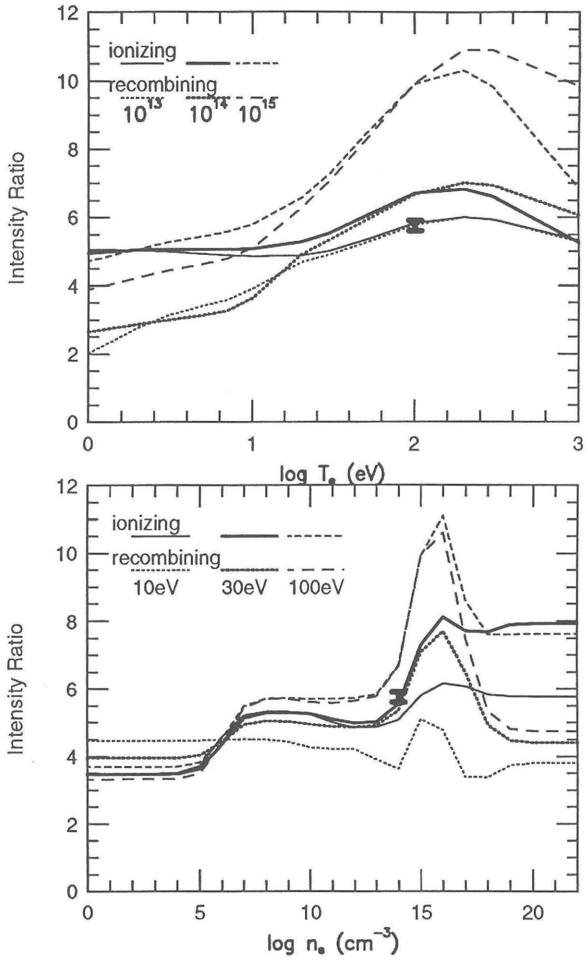

Figure 1: Line intensity ratio of 2s3s ^{3}S – 2s3p $^3P_2$ to 2s3s ^{3}S – 2s3p $^3P_0$ as a function of electron temperature (upper panel) and density (lower panel). Bar is measured ratio from Ref.[2].

We found that cascades from higher excited states can reproduce the measured line intensity ratios of OV triplet lines in Ref.[2]. We will apply this model for the OV lines measuered in LHD plasmas and investigate recombining phase plasmas.

References

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