§14. Collisional-radiative Model for OV Spectral Line Intensities and Comparison with LHD Measurements

Murakami, I., Kato, T., Kobuchi, T., Goto, M., Morita, S.,
Safronova, U.I. (Notre Dame University, USA)

Oxygen ions are often found as one of impurities in laboratory plasmas and OV spectral lines were measured by VUV and UV-visible spectrometers in the LHD plasmas in the Third Cyle. We have constructed a collisional-radiative model (CRM) for OV line intensities and compared calculated intensity ratios with the LHD measurements.

In the CRM we consider the excited states with the principal quantum number n up to $\sim$ 100 and all levels with $n \leq 6$ are J-resolved. Previous theoretical study on OV line intensities considered only low levels up to $n = 3$ ($2l2l'$,$2s3l$ states) and did not take into account any recombination processes [1, 2, 3, 4]. We take into account recombination processes from Li-like oxygen ions, radiative transitions, collisional excitation/de-excitation, and collisional ionization processes for each excited state. For collisional excitation rate coefficients, we use data calculated by R-matrix method for transitions among $2s2l$, $2p2l$, and $2s3l$ from Kato *et al.* [1]. For other transitions among $n \leq 6$ levels, we use 2 data sets: Model 1 uses data by Sampson *et al.* [5] for $2lnl'$-$2p3l''$ transitions and Mewe's emprical formula [6] for other transitions. Model 2 uses collision strength calculated by Hullac code [7]. We use empirical formula for $n > 6$ levels in both models. For recombination processes, dielectronic recombination rate coefficients are calculated with the use of Cowan code [8] by Murakami et al. [9]. Radiative recombination and three body recombination are also included to the CRM with the empirical formula.

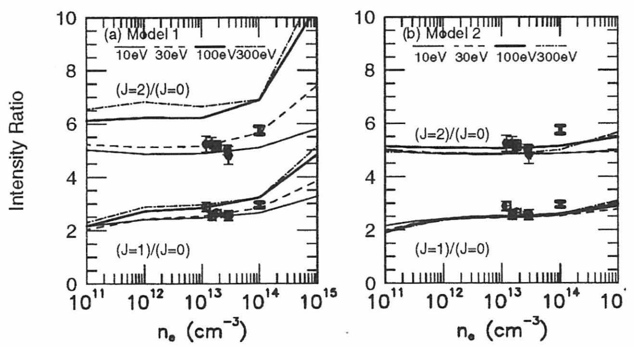

Figure 1: Line intensity ratios, (J = 2)/(J = 0) and (J = 1)/(J = 0) of 2s3s ^{3}S - 2s3p ^{3}P transitions as a function of electron density in ionizing plasma for model 1 (a) and model 2 (b). Circles with errors are measurements of the LHD and bar is from Ref.[4].

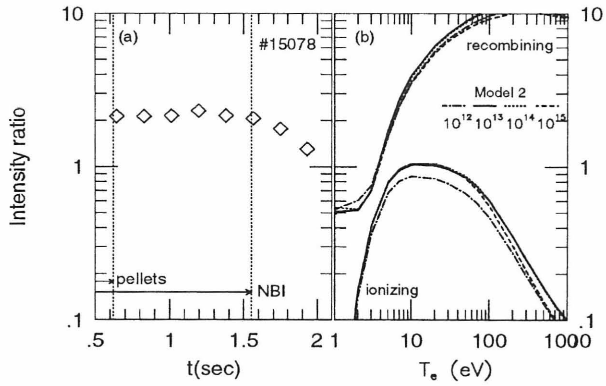

Figure 2: (a) Temporal distribution of intensity ratio I(2s2p ^{3}P $-$ 2p^2 ^{3}P)/I(2s^2 ^{1}S $-$ 2s2p ^{1}P) measured in the LHD experiments (shot no.15078). (b) The calculated intensity ratio of the same lines as in (a) for ionizing plasma (lower) and recombining plasma (upper) as a function of electron temperature for model 2.

From the LHD measurements we have line intensity ratios of 2s3s ^{3}S - 2s3p ^{3}P$_J$ (J=0,1,2) ($\lambda\lambda$ 2781, 2787, 2790 Å), and ratio of 2s^2 ^{1}S - 2s2p ^{1}P (λ 630 Å) (the resonance line) and 2s2p ^{3}P - 2p^2 ^{3}P (λ 760 Å) and compare with calculated ratios in Figs.1 and 2. In Fig.1, the LHD measurements agree with both models, and the model 1 indicates lower electron temperature, while the model 2 shows weak temperature dependence.

However, the intensity ratio of 2s^2 ^{1}S - 2s2p ^{1}P and 2s2p ^{3}P - 2p^2 ^{3}P is hard to explain with the present CRM for NBI heated phase which is thought to be ionizing plasma (Fig.2). The triplet line is much stronger than expected, and we need extra mechanism to obtain such strong intensity. One possibility is the inner-shell ionization from B-like ions to Be-like excited states. This is quite effective when electron temperature is higher than 100eV. We will examine this effect in future. The ratio in recombining phase after NBI turned off can be reproduced by the calculated one in recombining plasma.

References

[1] T. Kato, J. Lang, K. E. Berrington, At. Data Nucl. Data Tables, **44** (1990) 133
[2] F.P.Keenan et al., Astrophys. J. **382**, 349 (1991).
[3] F.P.Keenan et al., Mon. Not. R. Astron. Soc. **276**, 915 (1995).
[4] T. Kato, et al., J. Phys. B, **29** (1996) 4241
[5] D.H.Sampson et al., At. Data Nucl. Data Tables **30**, 125 (1984).
[6] R.Mewe, Astron. Astrophys., **20**, 215 (1972).
[7] A.Bar-Shalom et al., Phys. Rev. A **38**, 1773 (1988).
[8] Cowan R D 1981 *The theory of atomic structure and spectra*, University of California Press
[9] I. Murakami, U. I. Safronova, T. Kato, NIFS-DATA-66 (2001).