§24. Construction of a Molecular Hydrogen Collisional-radiative Model for Ionizing and Recombining Plasmas

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We are constructing a collisional-radiative model of molecular hydrogen in which the electronic state, the vibrational state v, and the rotational state J are considered. This model is used to deal with molecular processes whose cross sections depend strongly on the initial vibrational and rotational states, e.g., the dissociative attachment. The number of 4133 levels for the principal quantum number $n < 7$ are considered. In the present study, we included this model into our neutral transport code for LHD plasmas.

A particle released from the divertor plate penetrate the divertor plasma around the plate. However, information on atoms and molecules released at the divertor plate and the electron temperature T_e and density n_e of the divertor plasma, which are necessary for the neutral transport code, are not well known. In addition, information on atoms and molecules released from the vessel wall after collision of atoms with the wall is not well known. We investigate these source and wall conditions which reproduce the line intensity of atoms (Balmer α) and molecules (fulcher band), and the profile of Balmer α emission of atoms (Shot Number 123334, Time 3 s,1-O port) measured by Fujii and Hasuo (Kyoto Univ.). Figure 1 shows poloidal cross section of the spectroscopic measurement. Figure 2(a) shows a line-of-sight emission spectra measured by an echelle spectrometer at z= -0.026 m. Figure 3 shows line profiles of the atomic Balmer α measured by a high-resolution spectrometer.

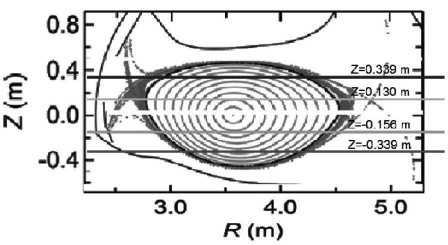

Fig. 1: Poloidal cross section of the spectroscopic measurement. The line-of-sights are shown.

The divertor plasma is not set in the model because data for T_e and n_e are not available. In the present model, a particle released from the divertor plate should be interpreted as one released from the surface of the divertor plasma. Initial state of the molecule, under this interpretation, is assumed to $X^1\Sigma_g^+(v=0)$. Rotational distribution is fixed to that for temperature of 300 K through the trace of molecules. Relative emission intensity of hydrogen species obtained by the transport code is normalized to the measured absolute intensity at the wavelength of the Balmer α. In calculating the line profile of the Balmer α, Doppler broadening and Zeeman splitting are considered.

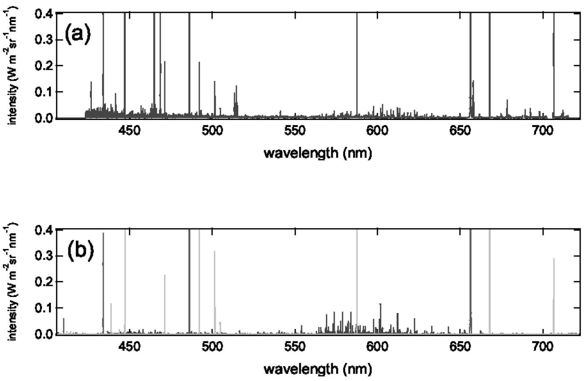

Fig. 2: (a) Measured and (b) calculated line-of-sight emission spectra at z= -0.026 m .

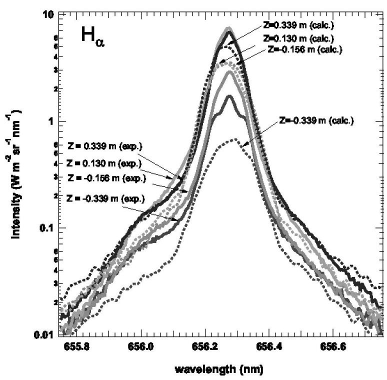

Fig. 3: Measured (solid) and calculated (dotted) line profiles of the atomic Balmer α.

Figures 2(b) and 3 show a result which reproduces the measured data relatively well among results for the various conditions. The flux ratio of atoms and molecules released at the source is 1:1, and that for the release at the vessel wall after the collision of the atom is 1:1. At the vessel wall, it is assumed that molecules have energy corresponding to 300 K and atoms have the same energy as that before colliding to the vessel.

In Fig.2(a), in the wavelength region below 500 nm, emission lines except large intensity atomic lines are thought to be originated from molecular hydrogen. The calculated molecular emission line intensity is smaller than the observed one. We will investigate this discrepancy.