§68. Measurement of Vibrational Temperature of Hydrogen Molecules in Periphery Region of LHD

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The neutral pressure in the Helical Divertor (HD) has to be enhanced by more than one order of magnitude compared to that under the present open divertor condition. In high gas pressure, the vibrationally excited hydrogen molecules, $H_2(v'')$, in their electronic ground state play a significant role in periphery region of HD because of the increase in ionization and dissociation rate coefficients. In order to understand the role of the $H_2(v'')$ in the divertor plasma, measurements of the ground-state vibrational temperature of hydrogen molecules, T_{vib}, have been given by vacuum ultraviolet (VUV) lights in the spectral range 80-180 nm. In the VUV wavelength region from 80 to 180 nm, there are two strongest band system for H_2 (the Lyman-band and the Werner-band) for atomic hydrogen. In this paper, T_{vib} can be found which results in a best fit the calculated VUV spectrum to the observed relative intensities of VUV spectrum.

The corona model used to calculate the population distribution of the vibrational levels resulting from a Boltzmann population distribution in the ground state characterized by a temperature of hydrogen molecule. The calculated relative intensities of VUV spectrum of the transitions from $B^1\Sigma_u^+(v') \rightarrow X^1\Sigma_g^+(v'')$ (the Lyman-band), $C^1\Pi_u(v') \rightarrow X^1\Sigma_g^+(v'')$ (the Werner-band), and $D^1\Sigma_u(v') \rightarrow X^1\Sigma_g^+(v'')$ are given by

$$I_{Xv''}^{Bv',Cv',Dv'} = \frac{A_{Xv''}^{Bv',Cv',Dv'}}{\sum_{v'} A_{Xv''}^{Bv',Cv',Dv'}} \frac{hc}{\lambda_{Xv''}^{Bv',Cv',Dv'}} n_e \sum_{v} \left\{ c_{Xv}^{Bv',Cv',Dv'} n_{Xv} \, exp\left[-\frac{G_X(v)}{kT_{vib}^X} \right] \right\}, \tag{1}$$

where, $A_{Xv''}^{Bv',Cv',Dv'}$ is spontaneous emission coefficient. $\lambda_{Xv''}^{Bv',Cv',Dv'}$ is the wavelength of the measured line, $G_X(v)$ is the vibrational energy in the $X^1\Sigma_g^+$ state, $c_{Xv}^{Bv',Cv'Dv'}$ is the electron impact excitation rate from the $X^1\Sigma_g^+(v)$ state to the $B^1\Sigma_u^+(v')$, $C^1\Pi_u(v')$, and $D^1\Sigma_u(v')$ states, respectively. [2)]

Figure 1 shows the VUV spectra of the intensity compared to the predicted result (except the Lyman α, β, γ for atomic hydrogen) by calculation of model with that of the experimental result at T_e = 14 eV, $n_e = 9.3x10^{17} m^{-3}$ and P= 0.07 Pa in the linear plasma device TPD-SheetIV.[1)] The solid line represents the experimental results. The dotted line and the dashed-dotted line give the calculated results with radiation trapping and without one, respectively. T_{vib} can be estimated which results in a best fit to the observed relative intensities of VUV spectrum in the range from 90 nm to 150 nm. The calculated values and the experimental results show good agreement, provided that radiation trapping effects are taken in account.

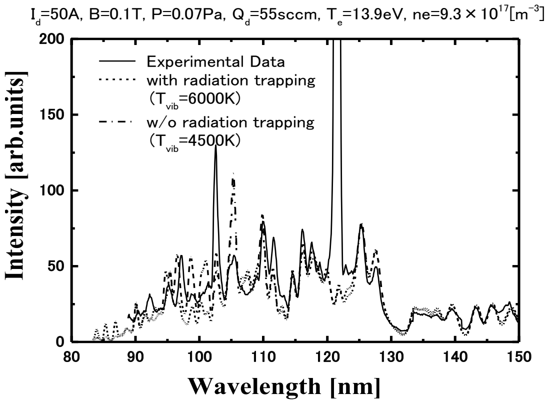

Fig. 1 VUV spectra of the intensity compared to the predicted result by calculation of model with that of the experimental result in the linear plasma device TPD-SheetIV.

Figure 2 shows the VUV spectra of the intensity compared to the predicted result by calculation of model with that of the experimental result in periphery region of LHD. As a results, it is estimated that the vibrational temperature hydrogen molecules, T_{vib}, is around 6000 K and the electron temperature is around 15 eV.

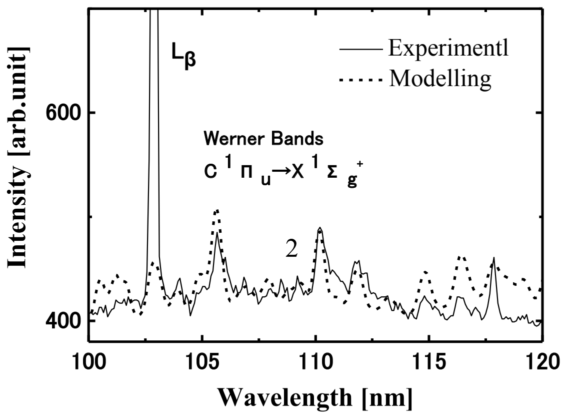

Fig. 2 VUV spectra of the intensity compared to the predicted result by calculation of model with that of the experimental result in periphery region of LHD.

1)A.Tonegawa, T.Nishijima, M.Ono,K.Kawamura, J.Plasma Fusion Res.SERIES **2** (2007)1079-1083.
2)A.Nakanowatari, A.Tonegawa, T.Shibuya, K.Kawamura, Journal of Nuclear Materials, **390-391** (2009)311-314.