§19. Effect of Vibrational Excitation of Molecular Hydrogen on Hydrogen Recycling in LHD Edge Plasma

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We have constructed a neutral particle transport code which contains recent atomic and molecular data especially concerning the molecular assisted recombination (MAR) which may enhance the plasma recombination in the higher temperature region where the conventional collisional-radiative recombination becomes ineffective. Figure 1 shows the rate coefficients of the MAR.[1)]

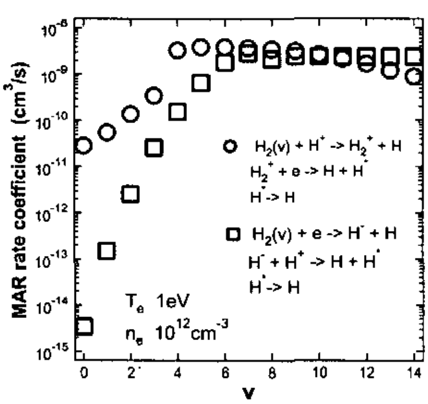

Fig.1. The MAR rate coefficients from various initial vibrational levels in $H_2(X^1\Sigma_g^+)$. T_e = 1eV, $n_e = 10^{12}$cm^{-3}. Because the MAR rate coefficient strongly depends on initial vibrational levels of $H_2(X^1\Sigma_g^+, v)$, the $v = 0-15$ levels are distinguished in our code. All atomic and molecular processes considered are listed below.

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------------------------------------------------------------
• H+  +  e  ->  H
• H   +  e  ->  H+  +  e  +  e
• H   +  H+ ->  H+  +  H
------------------------------------------------------------
• H2(v)  +  e     ->   H2(b)  +  e  ->  H  +  H  +  e
• H2(v)  +  e     ->   H2(v+1 or v-1)  +  e
• H2(v=14)  +  e  ->   H2(v=continuum)  ->  H  +  H  +  e
• H2(v)  +  H+       ->  H2+(v)  +  H
• H2(v)  +  e     <->  H2*  +  e
       H2*  ->  H2(b)      ->  H  +  H  +  e
       H2*  ->  H2(v= continuum)  ->  H  +  H  +  e
       H2*  ->  H  +  H+  +  2e
       H2*  ->  H2+(v')   +  2e
• H2(v)  +  e  ->  H  +  H*  +  e
           H*  ->  H
           H*  ->  H+  +  e
• H2(v)  +  e  ->  H  +  H+
• H2(v)  +  e  ->  H2+(v')  +  e
------------------------------------------------------------
• H2+(v)  +  e  ->  H  +  H+  + e
  H2+(v)  +  e  ->  H  +  H*  ->  H  +  H+  +  e
• H2+(v)  +  e  ->  H  +  H*  ->  H  +  H
------------------------------------------------------------
• H2  +  H+    ->  H2  +  H+     elastic collision
• H   +  H+    ->  H   +  H+     elastic collision
```

Figure 2 and 3 show some output examples of a calculation under a condition that uniform T_e = 1eV and $n_e = 10^{12}$cm^{-3} are assumed for $\rho \geq 1.0$ region where available data of these parameters is few. The vibrational level of $H_2(X^1\Sigma_g^+)$ which is released from the divertor plate is set to $v = 0$ in this calculation.

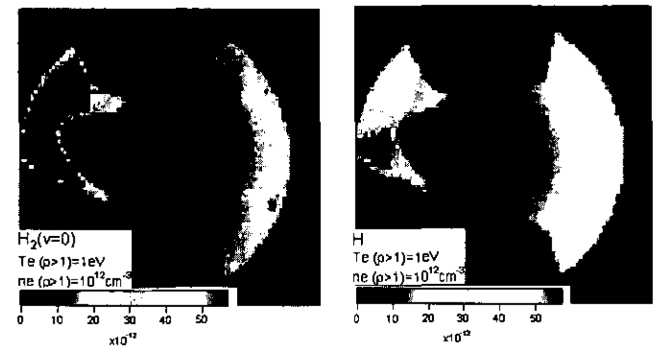

Fig.2. Density distributions of $H_2(X^1\Sigma_g^+, v = 0)$ and H(1s). For $\rho \geq 1.0$ region, uniform T_e = 1eV and $n_e = 10^{12}$cm^{-3} are assumed.

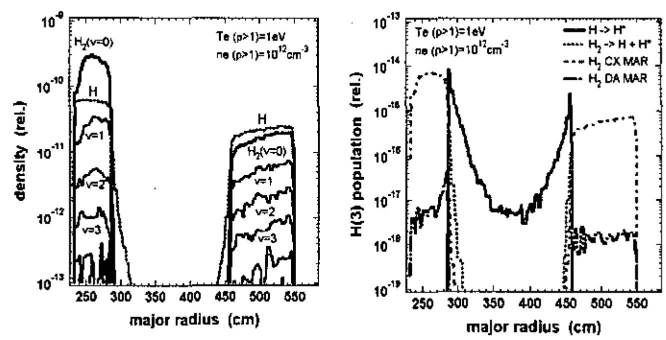

Fig.3. (a) Densities of $H_2(X^1\Sigma_g^+, v)$ and H(1s), and (b) Balmer α emission intensities originating from various paths, along center horizontal line in Fig.2.

Figure 3(b) shows that the Balmer α is emitted uniformly in $\rho \geq 1.0$ region, but no experimental evidence of the emission region is reported: the Balmer α is observed in limited region around $\rho = 1.0$. Our code can produce the spatial distributions of the densities of the various excited levels of atoms and molecules, and spectral line intensities and profiles emitted by them. However, in order to analyze LHD plasma quantitatively, the following items should be further investigated: (1) T_e and n_e for $\rho \gtrsim 1.0$ region, (2) a realistic wall reflection model (reflection probability, species, excited levels, direction, energy, etc.). In addition to accumulating information, we will study them by analyzing measured line intensities and profiles emitted by hydrogen atoms and molecules, and helium atoms.

Reference

1) K. Sawada and T. Fujimoto, Contributions to Plasma Physics **42**, (2002) 603.