§34. Construction of Neutral Transport Code for LHD Edge Plasmas

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We are constructing a hydrogen neutral transport code for LHD plasmas in order to analyze spectroscopically measured atomic and molecular emission line intensities and profiles. In the code, various inelastic and elastic atomic and molecular processes are considered. In this study, we have included H_2 -H_2 and H -H_2 elastic collision processes into our code using newly developed iteration method. All the processes in our code are listed in Table below.

The outline of our approach is as follows: **(1)** Run the neutral transport code neglecting H_2 -H_2 and H -H_2 elastic collision processes. **(2)** Determine absolute densities of the neutral species using measured absolute intensity of atomic hydrogen Balmer α emission line. **(3)** Run the code considering H_2 -H_2 and H -H_2 elastic collision processes using H_2 density calculated in step (2). **(4)** Repeat steps (2)-(3). This iterative process is continued until the above values converge.

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\begin{aligned}
\mathrm{H} + e &\rightarrow \mathrm{H}^+ + e + e \\
\mathrm{H} + e &\rightarrow \mathrm{H}^* + e \\
\mathrm{H}^* + e &\rightarrow \mathrm{H}^+ + e + e \\
\mathrm{H} + \mathrm{H}^+ &\rightarrow \mathrm{H}^+ + \mathrm{H} \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H}_2(b^3\Sigma_u^+) + e \rightarrow \mathrm{H} + \mathrm{H} + e \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H}_2(X^1\Sigma_g^+, v+1 \text{ or } v-1) + e \\
\mathrm{H}_2(X^1\Sigma_g^+, v=14) + e &\rightarrow \mathrm{H}_2(X^1\Sigma_g^+, v=\text{cont.}) \rightarrow \mathrm{H} + \mathrm{H} + e \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + \mathrm{H}^+ &\rightarrow \mathrm{H}_2^+(v') + \mathrm{H} \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H}_2^* + e \\
\mathrm{H}_2^* &\rightarrow \mathrm{H}_2(b^3\Sigma_u^+) \rightarrow \mathrm{H} + \mathrm{H} + e \\
\mathrm{H}_2^* &\rightarrow \mathrm{H}_2(X^1\Sigma_g^+, v=\text{cont.}) \rightarrow \mathrm{H} + \mathrm{H} + e \\
\mathrm{H}_2^* &\rightarrow \mathrm{H} + \mathrm{H}^+ + 2e \\
\mathrm{H}_2^* &\rightarrow \mathrm{H}_2^+(X^2\Sigma_g^+, v') + 2e \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H} + \mathrm{H}^* + e \\
\mathrm{H}^* &\rightarrow \mathrm{H} \\
\mathrm{H}^* &\rightarrow \mathrm{H}^+ + e \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H} + \mathrm{H}^+ + 2e \\
\mathrm{H}_2(X^1\Sigma_g^+, v) + e &\rightarrow \mathrm{H}_2^+(X^2\Sigma_g^+, v') + e \\
\mathrm{H}_2^+(X^2\Sigma_g^+, v') + e &\rightarrow \mathrm{H}_2^+(X^2\Sigma_g^+, v'') + e \\
\mathrm{H}_2^+(X^2\Sigma_g^+, v'') + e &\rightarrow \mathrm{H} + \mathrm{H}^+ + e \\
\mathrm{H}_2^+(X^2\Sigma_g^+, v'') + e &\rightarrow \mathrm{H} + \mathrm{H}^* \rightarrow \mathrm{H} + \mathrm{H}^+ + e \\
\mathrm{H}_2^+(X^2\Sigma_g^+, v'') + e &\rightarrow \mathrm{H} + \mathrm{H}^* \rightarrow \mathrm{H} + \mathrm{H} \\
\mathrm{H}_2^+ + \mathrm{H}_2 &\rightarrow \mathrm{H}_3^+ + \mathrm{H} \\
\mathrm{H}_3^+ + e &\rightarrow \mathrm{H} + \mathrm{H} + \mathrm{H} \text{ or } \mathrm{H}_2 + \mathrm{H} \\
\mathrm{H}_2 + \mathrm{H}^+ &\rightarrow \mathrm{H}_2 + \mathrm{H}^+ \quad \text{elastic collision} \\
\mathrm{H} + \mathrm{H}^+ &\rightarrow \mathrm{H} + \mathrm{H}^+ \quad \text{elastic collision} \\
\mathbf{H_2} + \mathrm{H_2} &\rightarrow \mathbf{H_2} + \mathrm{H_2} \quad \text{elastic collision} \\
\mathrm{H} + \mathbf{H_2} &\rightarrow \mathrm{H} + \mathbf{H_2} \quad \text{elastic collision}
\end{aligned}
$$

Figures 1(a) and 1(b) show calculated density distribution of $H_2(v = 0)$ in the vertical cross section including LHD#1-O viewing line. Figures 2(a) and 2(b) show calculated population of the upper state of the Balmer α on the viewing line in Fig.1. Difference of the results in Figs.2(a) and 2(b) is small. This is because excited atoms is produced from molecules on the surface of the plasma and the absolute neutral densities are determined by the measured Balmer α absolute intensity.

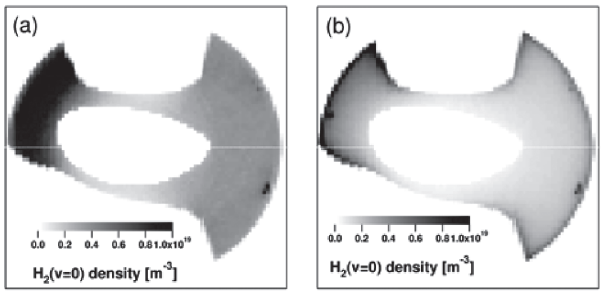

Fig.1. $H_2(v = 0)$ density. The neutral-neutral elastic collision processes: (a) not considered. (b) considered. White line is LHD#1-O viewing line.

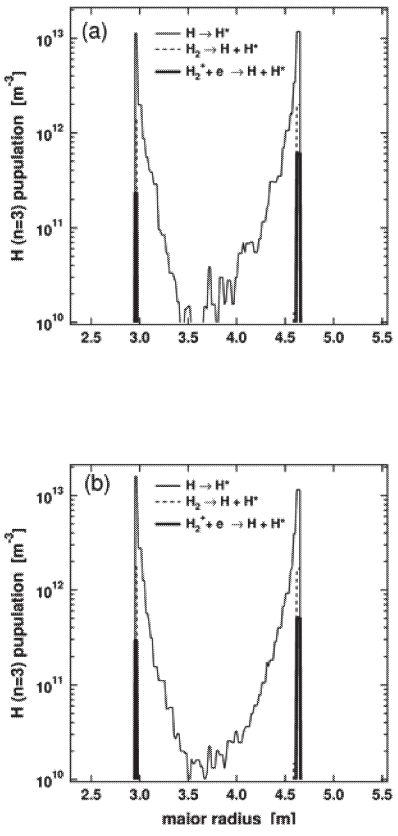

Fig.2. Hydrogen atom $n = 3$ excited state population. The neutral-neutral elastic collision processes: (a) not considered. (b) considered.