§18. Self-Consistent Computation of Radiation Transfer in Edge Plasmas Based on Collisional Radiative Model and Neutral Transport Model

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In divertor plasmas, radiation trapping is sometimes quite substantial. In applying the standard collisional-radiative model to such plasmas, we must properly include the effect of radiation trapping.

We have developed an iterative method which is based on the following algorithm: **(1)** Divide space into cubic cells of linear dimension Δl. **(2)** Give the ground state atom density $n(1)$, the ion density n_{H+}, the electron density n_e, the electron temperature T_e, and the line profile function $g_{pq}(\nu)$ for the transition from upper level p to lower level q for each cell. Set the frequency interval $\Delta\nu$ for the following calculation of emission and absorption. **(3)** Compute the population distribution of excited levels for each cell using the ordinal optically thin collisional-radiative model assuming no radiation trapping. **(4)** Compute the emission intensity radiated in each cell and the absorption in other cells using the population distributions obtained in step (3). **(5)** Compute the population distributions for each cell using the collisional-radiative model considering the absorption of photons. **(6)** Compute the emission intensity radiated in each cell and the absorption in other cells using the population distributions obtained in step (5). **(7)** Repeat steps (5)-(6). This iterative process is continued until the above values converge.

In order to calculate $n(1)$ and the Doppler profile $g_{pq}(\nu)$, we have constructed a neutral transport code for hydrogen species which includes the following list of atomic and molecular processes.

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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) + e -> H  +  H  +  e
・ H2(v)  +  H+       ->  H2+(v)  +  H
・ H2(v)  +  e     <->  H2*  +  e
      H2*  ->  H2(b)     ->  H  +  H
      H2*  ->  H2(v= continuum)  ->  H  +  H
      H2*  ->  H  +  H+  +  e
      H2*  ->  H2+(v')   +  e
・ H2(v)  +  e  ->  H  +  H*  +  e
           H*  ->  H
           H*  ->  H+  +  e
・ H2(v)  +  e  ->  H  +  H+  +  2e
・ H2(v)  +  e  ->  H2+(v')   +  2e
---------------------------------------------------------
・ 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
・ H2  +  H2    ->  H2  +  H2      elastic collision
・ H   +  H2    ->  H   +  H2      elastic collision
---------------------------------------------------------
```

We have applied our code to a RF cylindrical plasma ($P_{rf} \leq 2.0$kW, $f = 13.56$MHz) at Shinshu university. The gas pressure was 0.005Torr. Figure 1 shows calculated densities of atom and molecule, and atom temperature.

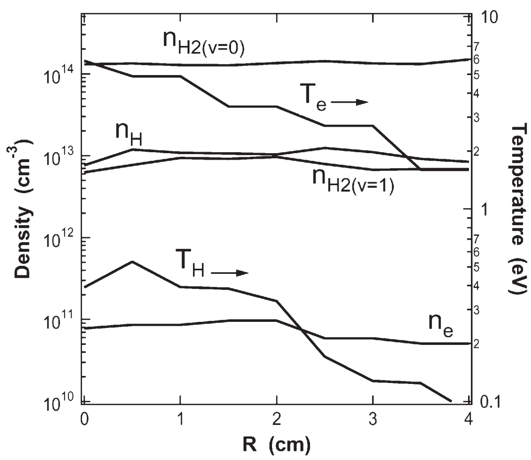

Fig.1. Calculated densities of atom and molecule, and atom temperature. Electron density and temperature measured by a double probe are also shown.

Figure 2 shows calculated populations of excited atom of the principal quantum number $n = 3$. Figure 2 also shows populations determined from measured intensities of the Balmer α. The calculated values agree precisely with the measured ones.

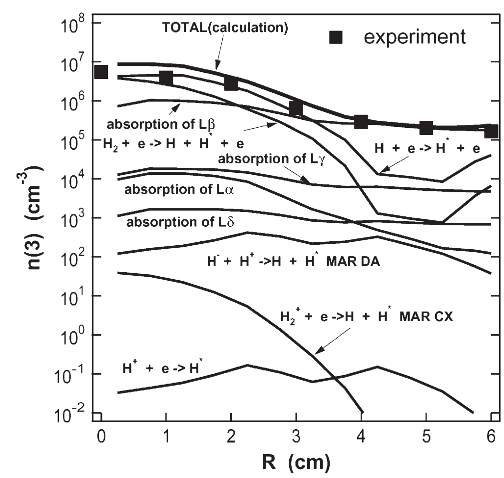

Fig.2. Calculated and measured populations of excited atom of the principal quantum number $n = 3$. The origins of the calculated populations of the excited atom are also shown.