# §24. EMC3-EIRENE Simulations of Linear Divertor Plasma Simulator NAGDIS-II

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We have adapted the Edge Monte Carlo 3D (EMC3) - Eirene code[1] for modeling of a linear divertor plasma simulator in order to demonstrate plasma-wall interactions with three-dimensional (3D) effects. 3D distributions of hydrogen plasma and neutrals can be successfully calculated for four different types of target plates: a V-shaped target, inclined targets with open and closed structures, and a planer target[2].

Figure 1 shows the calculated results with the V-shaped target plate. The plotted parameters are the electron temperature ($T_e$), the electron density ($n_e$), and H atom density in the 3D space. From the 3D view, it is found that the H distributions in the horizontal and vertical directions are different from each other.

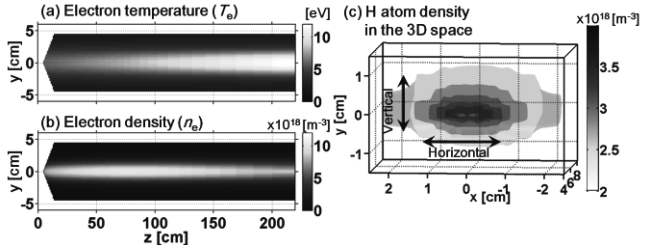


Fig. 1. Vertical distributions of calculated parameters with the V-shaped target plate at $x = 0$. (a) Electron temperature ($T_e$), (b) electron density ($n_e$). (c) H atom density in the 3D space.

Figure 2 shows the distributions of the H atom and $H_2$ molecule densities near the four different target plates ($z \leq 30$ cm). With the planar target plate [Figs. 2(g) and (h)], distributions of the H atom and $H_2$ molecule densities are similar, and their distributions are close to the inverse-square law. On the other hand, in the V-shaped target shown in Figs. 2(a) and (b), H atoms and $H_2$ molecules are strongly accumulated at the bottom of the V-shaped structure in comparison to the planer target case. For the inclined target plates with open and closed structures, distributions of the H atom density shown in Figs. 2(c) and (e) are almost the same, but distributions of the $H_2$ molecule density are quite different, as shown in Figs. 2(d) and (f). It is found that the closed target structure has more of an influence on the $H_2$ molecule density profile than on the H atom density profile.

Considering the target shape and the orientation of the target plate to the plasma, the $H_2$ molecules released from the inclined target plate without the closed baffle plate cross the plasma obliquely and therefore escape from the plasma more easily than from the planar target and the V-shaped target. From a geometrical point of view, the ability of neutral particles to escape from the plasma without ionization increases in the following order: the inclined target plate (closed structure) [Fig. 2(d)], the V-shaped target plate [Fig. 2(b)], the planar target plate [Fig. 2(h)], and the inclined target plate (open structure) [Fig. 2(f)]. As a result, the peak density of $H_2$ molecules decreases in the same order. The H atom distribution has a more complicated dependence on the geometries. The different peak positions of $H_2$ molecules and the electron density lead to a weak but broad source region of H atoms around $y = 0$ because H atoms are created from dissociation processes of $H_2$ molecules [see Figs. 2(c) and (e)]. On the other hand, the peak positions of H atoms and $H_2$ molecules in the V-shaped target and planar target coincide with each other, and therefore H atoms have a large localized source and a large density peak in the same position as the $H_2$ molecules. As mentioned before, the H atom and $H_2$ molecule densities increase more notably near the V-shaped target plate as compared to other target plates.

The enhanced H atom and $H_2$ molecule densities in the V-shaped target plate lead to a lower electron temperature and higher electron density than the planar target plate. These simulation results suggest that a V-shaped target plate contributes to plasma detachment more effectively, which is being demonstrated in the GAMMA 10/PDX[3].

In the next step, modeling of detached plasma in linear divertor plasma simulators with 3D target structures will be made by taking into account gas puffing ($H_2$, $D_2$, He, impurities), pumping, volume recombination (electron-ion recombination and molecular-assisted recombination) to simulate detached plasma experiments conducted in NAGDIS-II and GAMMA 10/PDX.

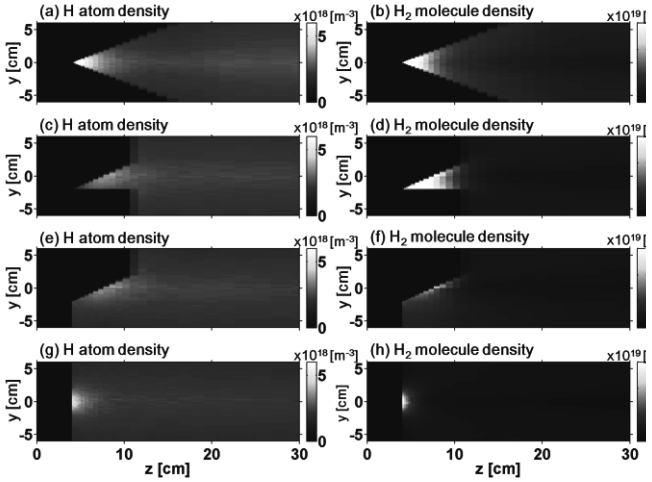


Fig. 2. Distributions of the H atom and $H_2$ molecule densities near (a, b) V-shaped target plate, (c, d) inclined target plate (closed structure), (e, f) inclined target plate (open structure), and (g, h) planar target plate on the vertical plate ($x = 0$).

1) Y. Feng *et al*., Contrib. Plasma Phys. **44** (2004) 57.
2) T. Kuwabara *et al*., to be pulished in Conrib. Plasma Phys.
3) M. Sakamoto *et al*., Trans. Fusion Sci. Technol. **63** (2013) 188.