Study of asymmetry in heat and particle loads on divertor tiles in LHD

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In the boundary plasma of the Large Helical Device (LHD), an asymmetry in heat and particle loads on divertor tiles installed at positions of symmetric magnetic field structure has been observed.[1-3] The asymmetric heat and particle loads can cause asymmetric erosion/deposition of plasma-facing materials, which can affect the lifetime of components and fuel accumulation in the vacuum vessel in fusion reactors. Hence, understanding the physical mechanism of the asymmetry should be considered for designing next-step fusion devices. In LHD, the asymmetry has been investigated in the standard magnetic configuration (a major radius of the magnetic axis R_{ax} of 3.6 m).[1, 3] However, we have not yet completely understood the physical mechanism causing the asymmetry observed in experiments. The purpose of this study is to reveal the physical mechanism of the asymmetry.

In order to understand the mechanism causing the asymmetric particle flux, we analyze the discharges in several experimental conditions including the standard magnetic configuration. There are two divertor tiles with Langmuir probe arrays in 7 of 10 toroidal sections. These are labeled as "R-array" and "L-array", as shown in Figure 1. The Langmuir probe array consists of 20 electrodes. The degree of the asymmetry (DOA) is defined as the ratio of the total ion saturation current at the L-array to that at the R-array. Figure 2 shows the dependence of DOA on the electron temperature at the last closed flux surface (LCFS) in the cases where the toroidal field direction is clockwise (CW) and counterclockwise (CCW). The asymmetry is reversed by changing the toroidal field direction including the effect of particle drifts. Figure 2 also shows the DOA is influenced by the difference in the magnetic configurations in which the magnetic field lines structure is different.

The data shown in Figure 2 are scattered, and plasma parameters changing the DOA have not yet been fully clarified. In order to find the plasma parameters changing the DOA, we adopt a Neural Network model.[4] As an example, Permutation Importance is used to find plasma parameters changing the DOA, which shows that the toroidal field direction is the primary factor. Plasma current, stored energy, NBI power, R_{ax}, and magnetic field strength are the secondary factors.

References

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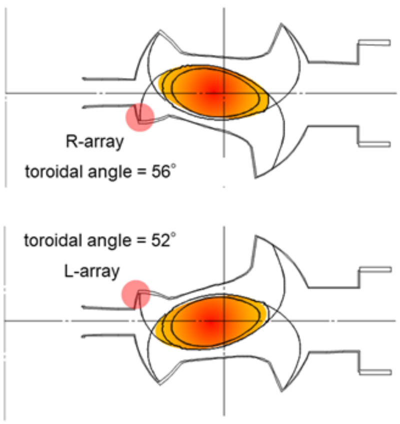

Figure 1. Poloidal cross-section at the toroidal positions where the Langmuir probe arrays are installed.

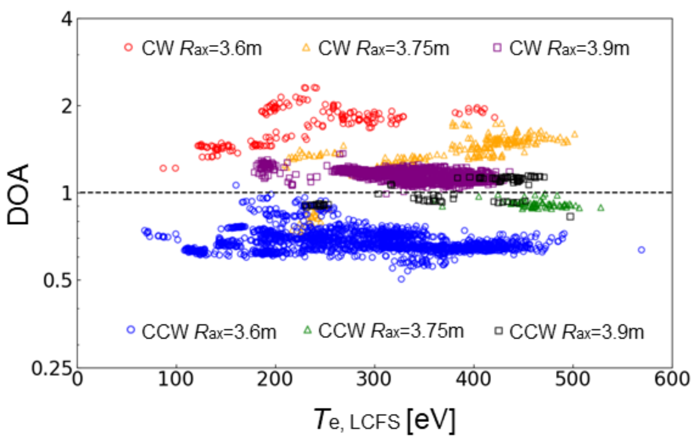

Figure 2. Degree of the asymmetry as a function of electron temperature at the LCFS in three different magnetic configurations (the major radius of the magnetic axis 3.6, 3.75, and 3.9 m).