§16. Study of Influence of Magnetic Field Structure on Detached Plasma Formation

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Plasma detachment is expected to one of the most promising method to reduce huge plasma heat loads to the divertor plate in next generation fusion devices. Now, new innovative divertor concept, such as super-X and snowflake divertor, is proposed. SXD and SFD have advantages to increase the connection length and plasma wetted area of target achieved by magnetic flux expansion. Furthermore, magnetically expanding plasma toward the divertor plate would have an advantage of stability of the plasma detachment.

On the other hand, higher plasma density and lower plasma parallel flow velocity are required to produce detached plasma more effectively because the higher plasma density with lower parallel flow velocity should enhance the volumetric plasma recombination. In magnetically expanding plasmas toward the divertor plate, plasma density goes down along the magnetic filed due to the flux expansion and plasma flow increases owing to a contrary effect of a magnetic mirror. These effects weaken the volumetric plasma recombination. Therefore, a magnetically expanding plasma may have a disadvantage for the formation of plasma detachment. In this report, the effects of magnetic field expansion and contraction on the detached plasma formation was investigated in a linear plasma device[1].

Figure 1 shows magnetic field strength at the center of vacuum vessel induced by the 20 solenoidal magnetic coils. In order to form the magnetic field expansion and contraction in axial direction, it is possible to separately operate 8 magnetic coils in upstream and 12 coils in downstream sides, respectively. The magnetic coil currents were applied to generate 0.1 T in upstream and 0.05 T in downstream for the expansion (solid line in Fig. 1), and 0.1 T and 0.2 T for the contraction (dashed line), respectively. When bias voltage for the target plate was fixed at -100 V, ion saturation current, I_{sat}, into the target plate could be measured.

Fig. 2 shows the I_{sat} measured at the target plate as the function of the magnetic field strength in downstream. Here, the magnetic field in upstream was set to 0.1 T constantly. By increasing the magnetic field in downstream, ion flux monotonically decreased, especially when the magnetic field was expanding towards the target plate. This result indicates that the magnetic field expansion strongly degrades formation of plasma detachment, and magnetic field contraction should contribute to enhancing the degree of detachment.

Furthermore, EMC3-Eirene code is adapted to simulate linear divertor plasma simulator firstly and 3D plasma and neutral distributions for four different types of target plates have successfully calculated. The simulation results indicate that hydrogen molecular density profile is influenced by the target structure more notably than hydrogen atom density profile. The V-shaped target plate and the inclined target plate with close structure give denser hydroge molecule near the target plate[2,3]

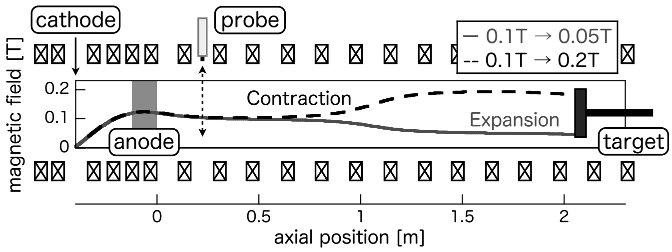

Fig. 1: Magnetic field strength at the center in a linear plasma deviceNAGDIS-II[1].

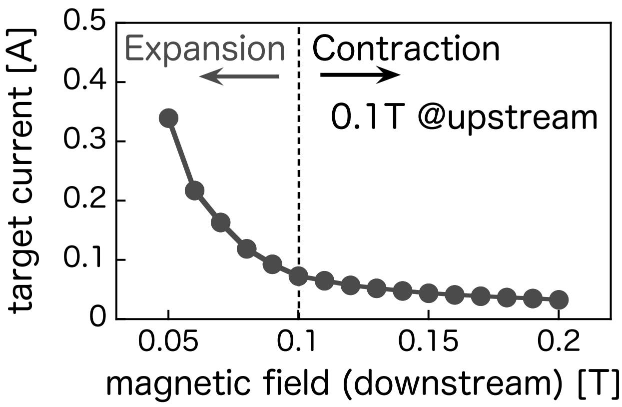

Fig. 2: Dependence of ion saturation current measured at the target plate on the magnetic field in downstream[1].

1) Yuki HAYASHI, Hayato NISHIKATA, Noriyasu OHNO and Shin KAJITA, Plasma and Fusion Research Volume 11, 1202005 (2016).

2) T.Kuwabara, H.Tanaka, G.Kawamura, N.Ohno, M.Kobayashi, Y.Feng, 15th International Workshop on Plasma Edge Theoryin Fusion Devices 2015.9.9-11 (Nara Kasugano International Forum IRAKA) (P2-01)

3) T. Kuwabara, H. Tanaka, G. Kawamura, N. Ohno, M. Kobayashi, Y. Feng, 24th International TOKI Conference, 2014, P4-60, Ceratopia Toki