§2. Central Density Limit of IDB Plasma

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The IDB (Internal Diffusion Barrier) is characterized by steep density gradient in core plasma and the attainable central density exceeds 1×10^{21} m^{-3} while keeping relatively low density mantle plasma which is surrounding the core[1, 2]. Under the existing experimental conditions, lack of neutral beam deposition in the core plasma due to the high density, put a ceiling on the attainable central density and pressure.

The experimental fact suggests advantage of the outward shifted preset magnetic axis configuration ($R_{ax} > 3.75$ m) to obtain high-density/high-pressure plasma. This preset magnetic axis dependence is not necessarily mean difference of the particle confinement property. For reasons that we shall go into later, a central heating property of a neutral beam injection (NBI) heating may explain the preset magnetic axis dependence of the attainable density under existing experimental conditions. The NBI power deposit calculation by using FIT code[3] indicates that the central heat deposition becomes inhibited as the density increases, and this tendency is particularly true for inward shifted magnetic axis configuration because the distance of the LCFS to magnetic axis along the neutral beam injection path increase as the magnetic axis become inward.

Fig. 1 shows comparison of heat deposition profile between preset magnetic axis; R_{ax}= 3.65 m and 3.85 m at the comparable central density $n_e(0) = 3 \times 10^{20}$ m^{-3} (Fig. 2(a)) with comparable NBI power (≈ 11 MW). Since the target plasma density is sufficiently high, total NBI power deposition is approximately 100 % in the both discharges. Despite the comparable total NBI power deposition, the heat deposition profile varies greatly according to the preset magnetic axis. In the case of R_{ax} = 3.85 m, peaked heat deposition profile is obtained. On the other hand, the heat deposition profile shows hollow distribution and fraction of the central heat deposition is strongly restricted in the case of R_{ax}= 3.65 m. Due to the lack of the central heating power deposition, central temperature at R_{ax}= 3.65 m is approximately half of that at R_{ax}= 3.85 m as shown in Fig. 2(b). It must be noted that the minimum central temperature after intensive pellet injection sequence is hardly less than 0.3 keV independently of discharge conditions. Under such a low temperature conditions, injected pellet passes through the plasma before the ablation is over and, therefore, the central density shows no effective increase. As the preset magnetic axis position becomes inwards, the central temperature drops to the minimum temperature, which is required to ablate the solid hydrogen pellet, at relatively low density due to lack of an effective central heating power as shown in Fig. 1. Therefore, preset magnetic axis dependence appears on the attainable density. Since the attainable central density is directly related to the central heating power as mentioned above, further extension of the operational space is expected even in the inward shifted magnetic axis configuration for which under gas puff fueling conditions excellent global confinement property is provided as long as sufficient central heating is available. Plasma heating with further high energy NBI is one of the options to lead further high-density/high-pressure plasma.

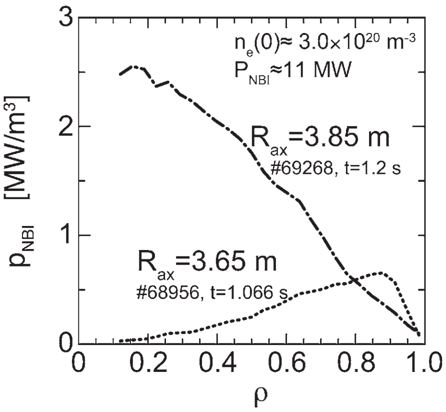

Fig. 1: A preset magnetic axis dependence of the NBI heat deposition profiles at $n_e(0) \approx 3 \times 10^{20}$ /m^3.

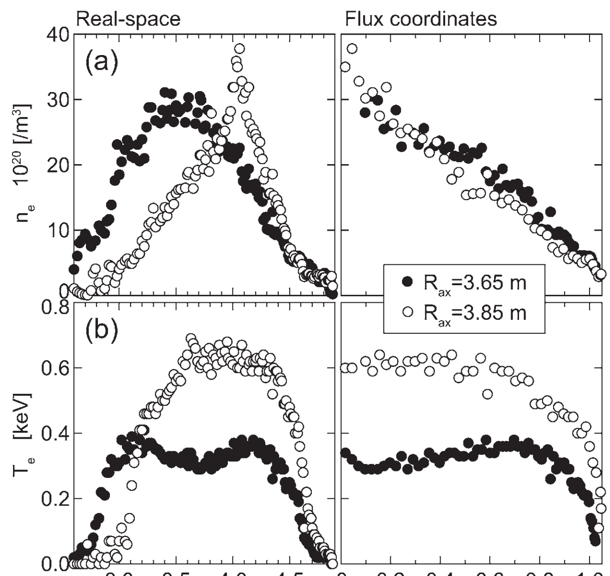

Fig. 2: (a) Density and (b) temperature profiles in the real-space coordinates and flux coordinates at $n_e(0) \approx 3 \times 10^{20}$ /m^3.

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2) R. Sakamoto *et al.*, Nucl. Fusion **49** (2009).
3) S. Murakami *et al.*, J. Plasma and Fusion Res. Ser. **2** (1999) 255.