§9. Study of the Physics of IDB Plasma and the Density Limit in Helical Devices

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In stellarators, there is no hard limit of the high-density operation, unlike the Greenwald density limit in tokamaks, which is one of great advantages for future reactor operation. Especially in LHD the operation condition for the IDB (Internal Diffusion Barrier) plasma was discovered and the high density/high pressure plasma was successfully produced. Therefore, it is important to study high-density plasma production and to explore the high-density operation in stellarators.

In Tohoku University Heliac (TU-Heliac) we obserbed the density collapse and the bursting high frequency fluctuations in the plasma which had ultra high speed poloidal flow (M_p >1)[1, 2]. The ultra high speed poloidal flow was sustained by the hot cathode biasing[3]. The density profiles showed the steep gradient around the core plasma region before the collapse. We adopted the conditional average to analyze the ion saturation signals and showed the availability of this method. The steep density profile collapsed accompanied with the bursting high frequency fluctuation (100 < f < 500 kHz), which had m = 2 ~3 poloidal mode number and the frequency agreed well with the $E \times B$ plasma rotating frequency.

In order to measure the radial distribution of the power spectrum in the ion saturation current before/after the sudden decrease in the density we measured the profile by the high speed triple probe scanning the radial direction. The decrease in the density was an eruptive event. Therefore we monitored the event by another single probe which was set at a toroidal angle φ = 90° and fixed at the magnetic axis and the spectrometer using the interferance filter (HeII, 468.6 nm). Figure 1 shows the ion saturation current signal at the magnetic axis and the intensity of HeII line. The arrows indicate the density collapse and two signales show the synchronized dips. We adopted the conditional average to analyze the fluctuation in the ion saturation current with the HeII line signal. The radial distributions of the power spectra of the high frequency fluctuations were shown in Fig. 2. Figure 2 (a) corresponds to the data before collapse (t = - 40μs), (b) just before collapse (t = 0 μs) and (c) after collapse. The high frequency fluctuations had the spectrum in the region of 100 < f < 500 kHz and the peak frequency of the spectrum was decreasing with increase in the radial position.

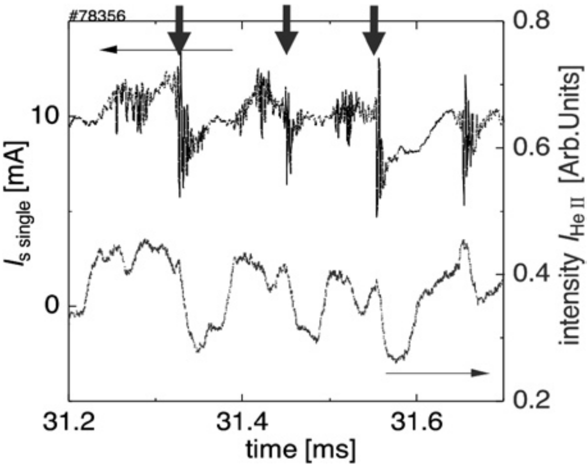

Fig. 1. Ion saturation current signal at the magnetic axis and the intensity of HeII line. The arrows indicate the density collapse.

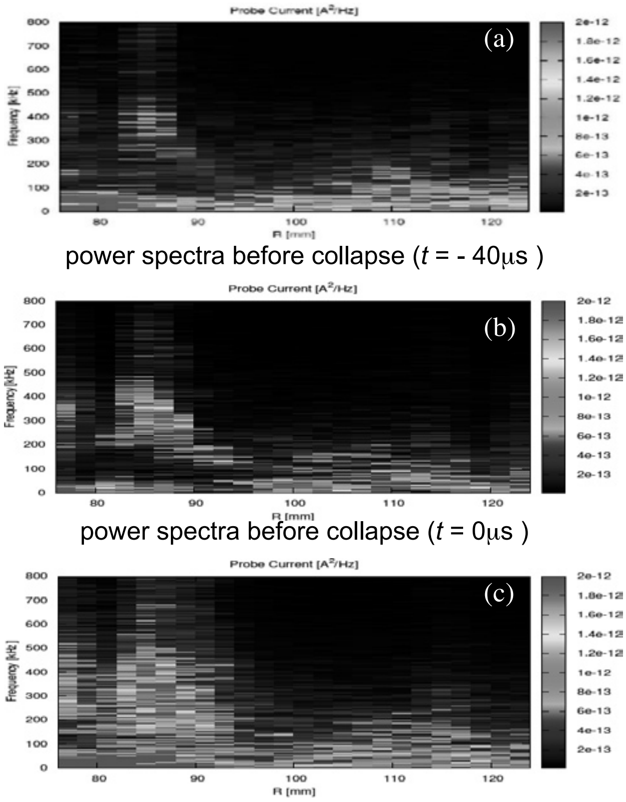

Fig. 2. The radial distributions of the power spectra correspond to (a) before collapse (t = -40μs), (b) before collapse (t = 0 μs) and (c) after collapse.

1) Tanaka Y. *et al* 2007 *Plasma Fusion Res*. **2** S1090.
2) Tanaka Y. *et al* 2008 *Plasma Fusion Res*. **3** S1055.
3) S. Kitajima *et al., Nucl. Fusion* **46** 200 (2006).