§3. Core Density Collapse Phenomena

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A highly peaked density profile is formed in the recovery phase after sequentially injected hydrogen pellets in the internal diffusion barrier (IDB)[1,2] type discharges. The central electron density reaches $1 \times 10^{21} m^{-3}$. A large Shafranov shift of the plasma ($\Delta r \sim 1/2 < a >$) with the increase of the central beta is one of the notable feature of these discharges. However, peaking of the plasma is terminated by the so-called core density collapse (CDC) events, by which the stored energy and the central electron density are decreased by several tens of percentage. In order to avoid CDC, we need to understand the mechanism.

The parameter dependence of the appearance of the CDC events is summarized by the following. 1) They appear when the magnetic axis exceeds a certain value (4.1m in horizontally elongated section). 2) When the Shafranof shift is reduced by the vertical elongation, higher central beta with similar amount of shift are observed when CDC occurs; this phenomena is related with the location of the magnetic axis rather than with the pressure gradient. 3) Typical time scale of the events is less than 1ms. It becomes shorter when the central electron temperature increases; the profile redistribution might be caused by the heat flow along the magnetic field lines.

Magnetic reconnection is thus a possible candidate for the explanation of the CDC. Fluctuations measured at a CDC event are shown in Fig. 1. In most cases, clear precursors of the events are not found. The events start with the decrease of the SX radiation (SXR) in the inboard (smaller major radius) side. That means the magnetic axis moves outward just before the events. While the SXR at the plasma center is being decreased (4.0m, 1.3325s– in Fig. 1(b)), discrete peaks in the SXR are often observed in the outboard side (4.0m- 4.2m in Fig. 1(b)). The phase of the peaks are different in the measurement at different toroidal cross sections (port 3.5 and 6.5). When the modification of the SXR profile completed, large amplitude of the magnetic fluctuations with toroidal mode number n = 2 are observed (Fig. 1(a) 1.333s–). Since there is no oscillation in SX signals correlated with magnetic fluctuations, those oscillations are localized in the very edge region where the pressure gradient there is increased after the CDC events. These characteristics is consistent with the idea that magnetic reconnection, well-localized one, occurs in the outboard side with the rapid shift of the magnetic axis. Observed peaks in SXR reflect the plasma blobs transferred from the plasma core along the magnetic field lines.

We still do not understand the cause of the initial outward movement. The linear stability analysis shows that it is well stable due to the formation of the magnetic well. We continue to study radial structure of the fluctuations in SXR in order that we can get an insight of the mechanism of this phenomenon.

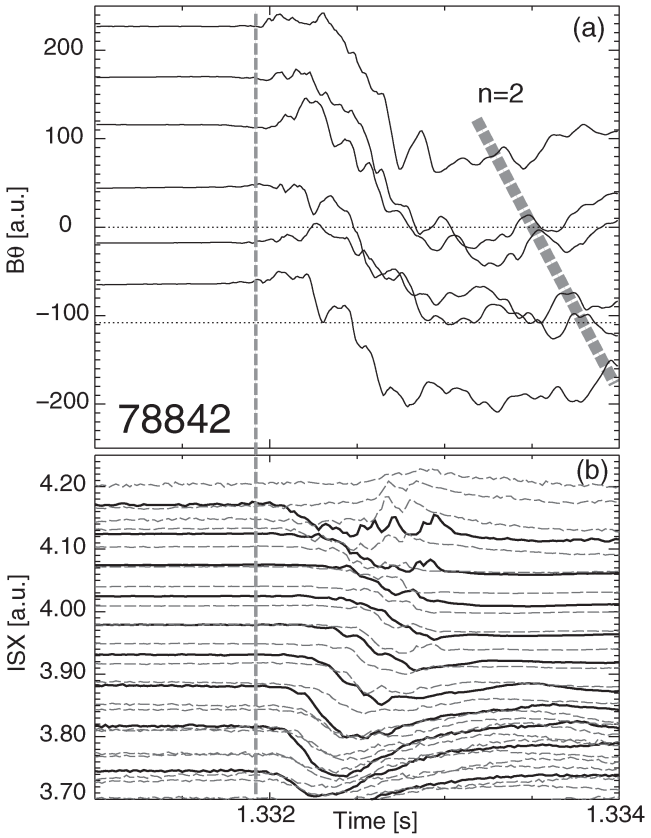

Fig. 1: Magnetic fluctuations (a) and soft X-ray radiation (b) observed in a CDC event are shown. Baseline of the each signal indicates the toroidal angle (a) and radial position (b) of the measurement, respectively. In Fig. (b), measurement at two different toroidal positions (6.5: solid line and 3.5: red dashed line) are plotted together.

[1] N. Ohyabu, et al., Phys. Rev. Lett., 97 (2006) 055002

[2] H. Yamada, et al., Plasma Phys. Control. Fusion, 49 (2007) B487-B496