§35. Ballooning-like Structure of Edge MHD Mode Observed in the LHD Plasmas with Externally Applied Magnetic Perturbations

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In the vacuum magnetic configuration of the Large Helical Device (LHD), the last closed flux surface (LCFS) is always surrounded by the ergodic layer [1]. In high beta (=plasma pressure/toroidal magnetic pressure) and/or L-H transition discharges of LHD, resistive interchange modes having lower mode numbers, i.e. m/n = 1/1, 1/2, 2/3, 3/4 and 3/5 (m, n: poloidal and toroidal mode numbers) are easily excited by steepening the pressure gradient in the ergodic region, because the region is characterized by high magnetic shear but the magnetic hill [2-5]. Figure 1 shows a typical example of the radial profile of Soft X-ray (SX) fluctuations of the m/n = 2/3 edge MHD mode observed in an L-H transition plasma on LHD and compares it with the simulation result based on a simple perturbation model of interchange mode. They agree very well each other. The observed radial profile obviously indicates the character of interchange mode that the fluctuation amplitudes at inboard (smaller major-radius) and outboard (larger major-radius) sides of the torus are almost the same.

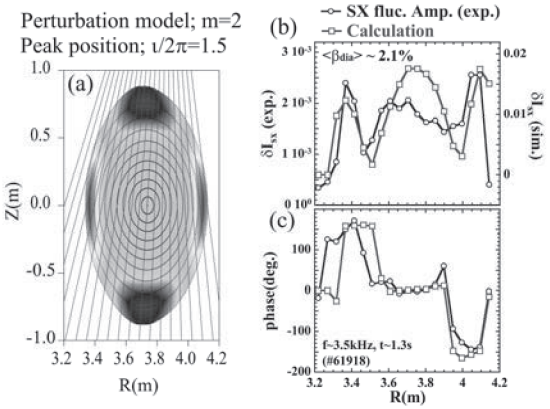

Fig. 1 Comparison of radial profile of SX fluctuation amplitudes of the m/n = 2/3 mode between experimental observation and a simple perturbation model; (a) Perturbation model and sight lines of an SX array, (b, c) Experimentally obtained radial profiles of SX fluctuation amplitude and phase difference of the m/n = 2/3 mode as a function of the major radius in the equatorial plane.

In LHD, a pair of perturbation field coils is installed on upper and lower port areas in 10 vertically elongated sections, of which coil set is called the Local Island Divertor (LID) coil and is able to generate resonant helical perturbation field of the m/n = 1/1. Recently, effects of a sizable m/n = 1/1 static island generated by the perturbation field on these edge MHD modes have been investigated [6]. In order to investigate the radial structure of edge MHD modes, we have carried out simultaneous measurements using SX arrays at two different vertically elongated sections which are away by 108 degrees in the toroidal direction. Three sets of SX arrays which consist of 20-channel PIN photodiodes are employed. Their sight lines are shown in Figs. 2(a) and 2(b) together with calculated Poincare plots of the m/n = 1/1 static island. In Figs. 2(c) and 2(d), the radial profiles of the SX intensity (I_{sx}) and its fluctuation amplitude (δI_{sx}) for the mixture of m/n = 2/3 and 3/4 edge MHD modes are shown. As seen from Figs. 2(a) and 2(c), the δI_{sx} at the 6.5U port is strongly enhanced near the O-point of the m/n = 1/1 static island. The feature of the δI_{sx} profile at the 3.5U port is also consistently explained by Figs. 2(b) and 2(d). These asymmetric evolutions of the δI_{sx} profiles are obviously different from the character of the interchange mode as shown in Fig. 1. In addition, there is a possibility that the large m/n = 1/1 perturbation field will tend to decrease the toroidal period number N = 10 to $N \sim 1$. Under the situation, the observed n = 3 and 4 modes might be a ballooning type mode corresponding to the tokamak-like ballooning mode excited through weak toroidal mode coupling [7], which are excited by the steep edge pressure gradient near the O-point of the m/n = 1/1 static island. However, the possibility of an interchange type mode deformed by the formation of the m/n = 1/1 static island cannot be ruled out so far. The above discussion should be improved by both experimental and theoretical approaches to draw the definite conclusion.

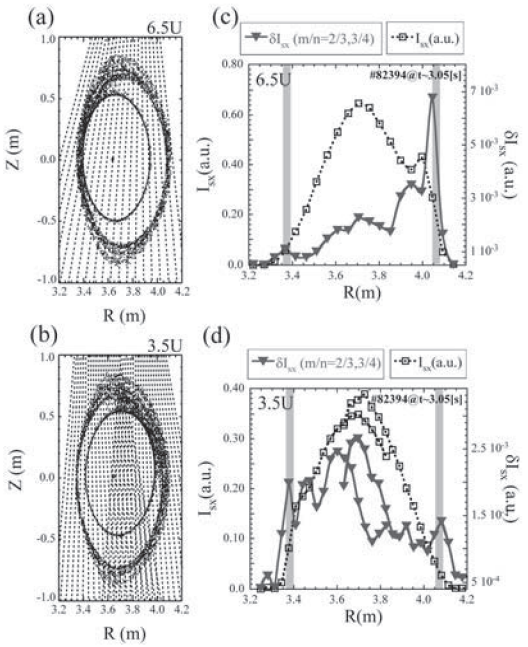

Fig. 2 (a, b) Calculated m/n = 1/1 static island and overlaid lines of sight of the SX arrays in different observation sections (3.5U and 6.5U ports). (c, d) Radial profiles of SX intensity (I_{sx}) and SX fluctuation amplitude (δI_{sx}) of the edge MHD modes, where the shaded zone indicates the inferred m/n = 3/4 rational surface.

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