§8. Measurement of 3-D Mode Structure of the Edge Harmonic Oscillations in CHS Using Beam Emission Spectroscopy

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A coherent magnetohydrodynamic fluctuation which has similar characteristics to the edge harmonic oscillation (EHO)[1] has been observed in the discharges having the edge particle transport barrier[2] in the compact helical system (CHS). In the present study, the 3-D spatial structure - radial locality and poloidal/toroidal mode numbers - of this fluctuation was investigated using beam emission spectroscopy (BES)[3] and the magnetic probe array.

Figure 1 shows the power density spectra of (a) the magnetic fluctuation, (b) the density fluctuation at ρ = 0.95, and (c) the density fluctuation at ρ = 0.53. These spectra were averaged over 100-140 msec, which is the period in which the coherent oscillation appears in the magnetic fluctuation. As shown in Fig. 1 (b), the edge density fluctuation has a frequency spectrum with 1st and 2nd harmonic components. We have called this mode "EHO" because of the shape of its spectrum and its locality, even though it has not yet been clarified whether or not the mechanism of this mode and that of the EHO in tokamaks are exactly the same.[4] There is a rational surface with the rotational transform ι = 1 at the position ρ = 0.97, which is near the peak position of EHO. Moreover, we found that there is a coherent fluctuation at the core region at ρ = 0.53 after the extension of the observable region. There is an ι = 0.5 rational surface at the position ρ = 0.5, which is near the position of this core mode. The shape of the frequency spectrum of the magnetic fluctuation is similar to that of the edge density fluctuation as shown in Fig. 1 (a) and (b). Therefore, this magnetic fluctuation has been regarded as the edge oscillation in our previous study.[4] However, recent observation has revealed that the frequencies of this mode differ slightly between the magnetic fluctuation (1st 3.5 kHz, 2nd 7.0 kHz) and the edge density fluctuation (1st 4.0 kHz, 2nd 8.5 kHz) as shown in these figures. On the other hand, as shown in Fig. 1 (a) and (c), the frequency of the core density fluctuation, 3.5 kHz, is exactly the same as that of the 1st harmonic of the magnetic fluctuation. These results indicate that the clear peaks of 3.5 kHz and 7.0 kHz in the magnetic fluctuation reflect the harmonic oscillation in the core (denoted as “HO (core)” hereafter) actually. Furthermore, a small peak of 8.5 kHz can be found in the magnetic fluctuation as shown in Fig. 1 (a), as the 2nd component of the harmonic oscillation in the edge (denoted as “HO (edge)” hereafter).

To confirm the existence of these two pairs of harmonic modes, the mode number of each mode was analyzed. Figure 2 shows the temporal evolutions of the (a) poloidal and (b) toroidal mode numbers of the 3.5 kHz, 7.0 kHz, and 8.5 kHz modes measured using magnetic probes. The signs are defined such that the ion diamagnetic direction and counterclockwise direction are positive for poloidal and toroidal mode numbers, respectively. The poloidal/toroidal mode number m/n of the HO (core) at the frequencies 3.5 kHz and 7.0 kHz was -2/1 while that of the HO (edge) 8.5 kHz mode was -1/1.

The 1st frequency of the HO (edge), 4.0 kHz, is difficult to find in the magnetic fluctuation spectrum because it is very close to the large 3.5 kHz peak. Therefore, we tried to measure the poloidal wavenumber of the 1st component of the HO (edge) directly using BES with the poloidally-aligned sightlines and obtained the poloidal mode number m = -1.[5]

These results lead us to the following conclusion. There are two pairs of harmonic oscillations in the ETB discharges in the CHS, one called HO (core) having the mode number m/n = -2/1 and located at ρ = 0.53 near the ι = 0.5 rational surface, and the other called HO (edge) having the mode number m/n = -1/1 and located at ρ = 0.95 near the ι = 1 rational surface. Note that the magnetic probes were sensitive to the HO (core). This fact means that we cannot distinguish the HO (core) and the HO (edge) without local measurement such as BES.

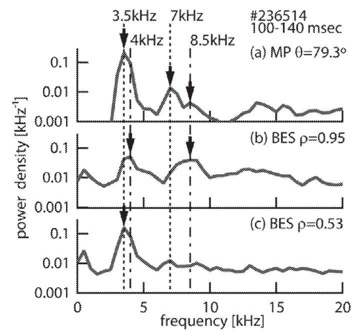

Fig. 1. Power density spectra of (a) the magnetic fluctuation, (b) the density fluctuation at ρ = 0.95, and (c) the density fluctuation at ρ = 0.53.

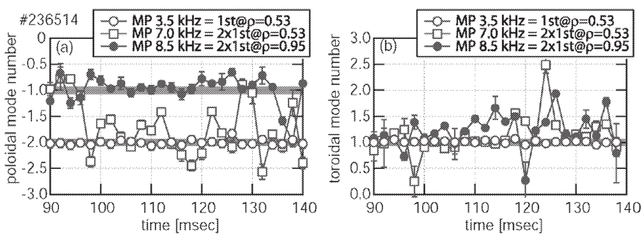

Fig. 2. Temporal evolutions of the (a) poloidal and (b) toroidal mode numbers of the 3.5 kHz, 7.0 kHz and 8.5 kHz modes.

Reference
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5) Oishi, T. et al., *to be published in* Plas. Fus. Res.