§6. 2-Dimensional Structure of Intermittent Electron Flux Observed in a Linear ECR Plasma

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It is well known that the magnetic fluctuation strongly affects the plasma dynamics in high-β plasmas such as magnetic fusion plasma and space plasma, where β is a ratio of the plasma pressure to the magnetic pressure. In the high-β plasma, intermittent magnetic field variation that induce particle and energy transport have frequently been observed.

Recently, the intermittent magnetic pulses (IMPs) have been observed in a very low-β cylindrical electron cyclotron resonance (ECR) plasma. The IMP has a typical duration of 10 μs, and is excited on almost of the whole plasma cross section. From the simultaneous measurement using magnetic probes and a directional Langmuir probe, it was found that the IMP is related to the intermittent high-energy electron flux (IHEF) parallel to the magnetic field line. The excitation mechanism of IMPs has not been understood so far, because of the difficulty of the measurement. Here, we have newly developed a wire-grid probe (WGP), and have examined the reconstruction of the spatial structure of the IHEF.

Experiments have been performed in the high-density plasma experiment-I (HYPER-I) device[1]. The HYPER-I device has a cylindrical vacuum chamber (2.0 m in axial length and 0.3 m in inner diameter) and 10 magnetic coils. A helium plasma is generated by ECR heating with a 2.45 GHz microwave, and the typical electron density and temperature are 10^{17} m^{-3} and 10 eV, respectively. A picture of the WGP is shown in Fig. 1. The WGP consists of eight horizontal and eight vertical electrically independent tungsten wires with a diameter of 0.7 mm, and each wire is separated from the adjacent wire with the distance of 10 mm. The WGP measures the floating potential (V_f) fluctuations in place of the electron current, because the floating potential is sensitive to the change of the high energy electron flux. The advantage of this measurement is that the disturbance to the plasma due to drawing large electron current can be avoided. The variation of electron flux at 64 lattice point, $\tilde{\Gamma}_{e,ij}$, is evaluated as

$$\tilde{\Gamma}_{e,ij} \propto \sqrt{\tilde{V}_{f,i} \times \tilde{V}_{f,j}}, \qquad (1)$$

where the symbols i $(= 1, 2, \cdots, 8)$ and j $(= 1, 2, \cdots, 8)$ are for the horizontal and the vertical wires, respectively, and tilde is for the perturbed quantity. Although the floating potential has nonlinear dependence on the electron flux, the non-linearity is not critical in our plasma parameters.[2] Thus we can evaluate the size of the IHEF by calculating the geometric mean of $V_{f,i}$ and $V_{f,j}$ for each lattice point.

Figure 2 shows the 2-dimensional profile of the IHEF on the plasma cross section at the axial position of 1.175 m, where the origin $(x, y) = (0, 0)$ corresponds to the center of the device. From the 80 samples of the IHEF, it was found that the IHEF has a convex shape and the typical size (diameter) is 35 ± 15 mm.

We have developed the WGP to study the spatial structure of the intermittent electron flux. The WGP can successfully capture the entire picture of the IHEF on the plasma cross section, and the size of the IHEF is typically 35 mm. This result allows us to apply the advanced statistical analysis, such as the condititonal averaging method and the higher order statistical analysis.

1) Tanaka, M.Y. et al., Rev. Sci. Instrum. **69** (1998) 980.

2) Cercek. M. et al., Contrib. Plasma Phys. **39** (1999) 541.

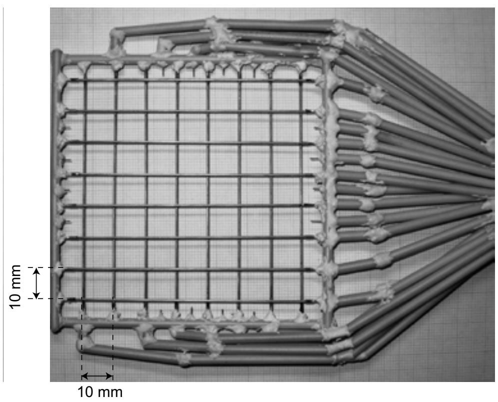

Fig. 1: Picture of a wire-grid probe.

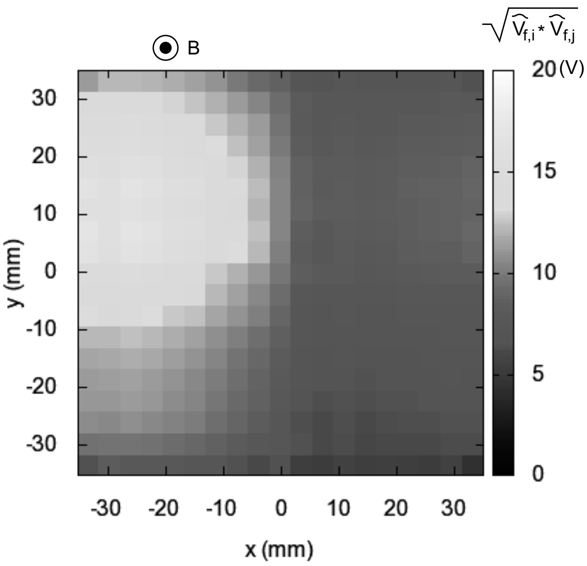

Fig. 2: Two dimensional structure of the IHEF.