§11. Study on Structural Formation in Magnetized Plasma Column

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Understandings of bifurcation and transport barrier and their formation mechanisms, which have been actively investigated in NIFS, are crucial for plasma confinement. The structural formation in cylindrical magnetized plasma is studied with an emphasis on helicon wave [1] structures imposed by the boundary conditions.

Experiments are carried out in the following conditions: With a pressure P (argon) of 0.75-10 mTorr using two devices [2-7], plasmas are produced by a RF wave of 7 MHz, and the axial plasma length is limited by the movable SUS termination plate. Plasma parameters (rf wave structures) are measured by Langmuir probes (magnetic probes). Typical plasma density and electron temperature were 10^{12} ~ 10^{13} cm^{-3} and 3 - 5 eV, respectively.

Figure 1 shows the radial profiles of the excited magnetic field (B_z component), changing the magnetic field near the antenna and also changing the antenna turn with z_E = 81 cm. Here, z_E means the position of the termination plate. From Figs. 1(a) to 1(c), radial wave structures become complex, showing the existence of higher order radial modes (normally only a fundamental mode [1] appears). The reason of this generation of higher order mode is not clear, but it may be related to the magnetic field configuration and/or the radial density profile.

Figure 2 shows the axial profiles of the excited magnetic field B_z, changing the axial length. In the case of the short axial length, with the decrease in z_E, the axial mode number n (the axial plasma length divided by the wavelength), which is discrete and can be expressed by $n = (1/4) + (p/2)$ (p = 0, 1, 2 …), decreases. The wavenumbers obtained satisfies the helicon wave dispersion relation [1]. This mode number n can be understood from the following discussions. On the termination plate, the nearly conducting boundary condition for the axial component of the rf magnetic field is expected, i.e., $B_z \sim 0$ (fixed boundary condition). On the inside of the quartz window, a nonconducting, free boundary condition is valid, implying that the axial component of the rf conduction current, j_z, vanishes, or that the rf electric field $E_z \sim 0$. The latter means that B_z is maximum rather than zero on the quartz window.

In conclusion, we have investigated the helicon rf wave structures by changing the boundary conditions. In the case of a short axial length, complex radial modes as well as discrete axial wavenumbers, which satisfy the helicon wave dispersion relation, are found. These understandings will be expected to contribute to the structural formation in plasmas.

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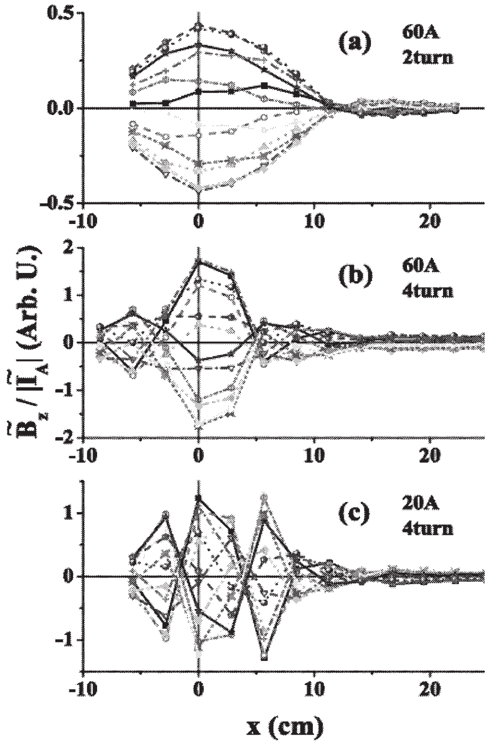

Fig. 1. Radial profiles of excited magnetic field (B_z component), changing the magnetic field near the antenna and also antenna turn.

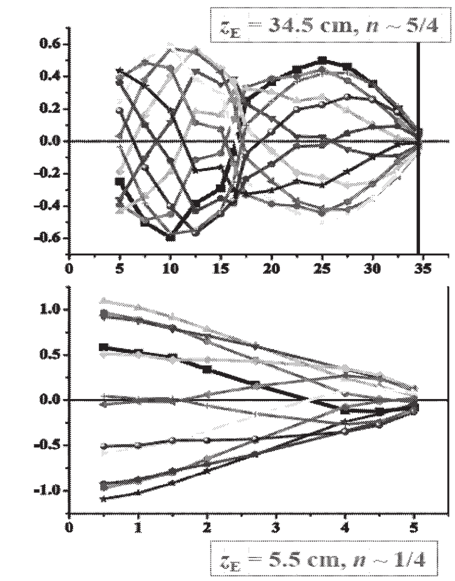

Fig. 2. Axial profiles of excited magnetic field (B_z component), changing the axial length.