§12. Study on High Beta Structural Formation in Cylindrical Magnetized Plasma

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Studies on high-beta (the beta β is the ratio of the plasma pressure to the magnetic one) plasma characteristics and bifurcation/transport barrier and also the clarification of their formation mechanisms, which have been actively investigated in NIFS, are crucial for plasma confinement. Here, the structural high-beta formation in cylindrical magnetized plasma is investigated by the use of the helicon wave scheme [1], with an emphasis of the high-density in the low magnetic field region.

Experiments are done in the following conditions: a fill pressure P (argon) of 3-10 mTorr using the Large Diameter Device (LDD) [2-4], 40 cm in diameter with 125 cm axial length, as shown in Fig. 1. Here, the high-density plasmas are produced by applying a RF wave of 7 MHz to the spiral antenna [5-6], and the axial plasma length is limited by the movable stainless steel termination plate. Plasma parameters (rf wave structures) are measured by Langmuir probes (magnetic probes). Typical electron density n_e and electron temperature were 10^{12}-10^{13} cm^{-3} and 3-5 eV, respectively.

Since n_e in the helicon high-density (~ 10^{13} cm^{-3}) regime is weakly dependent on the external magnetic field B, we can have the high-beta value with the low B. Figure 2(a) shows the central beta vale β_0 as a function of P and B. We can see the high-beta plasma with β_0 being close to 1, especially in the lower field region, applying the input rf power of 2 kW.

However, the decrement of the magnetic field even in high β_0 region is smaller than the expectation. Since the ion Larmor radius is smaller than the plasma radius, and the Hall parameter $\omega_c\tau$(ω_c: cyclotron angular frequency, τ: collision frequency) of electrons is larger than unity, this small decrement may come from the followings: $\omega_c\tau$ is less than unity for ions (unmagnetized), and the magnetic diffusion time on the order of several tens of μs is smaller than the discharge duration time.

In conclusion, we have successfully produced high-beta plasma with β_0 close to unity under the condition of the low magnetic field (40-60 G) and the high density (~ 10^{13} cm^{-3}). For future, the reason why the smaller decrement of the magnetic field must be clarified, and it is important to study the plasma structure with the high beta condition afterwards.

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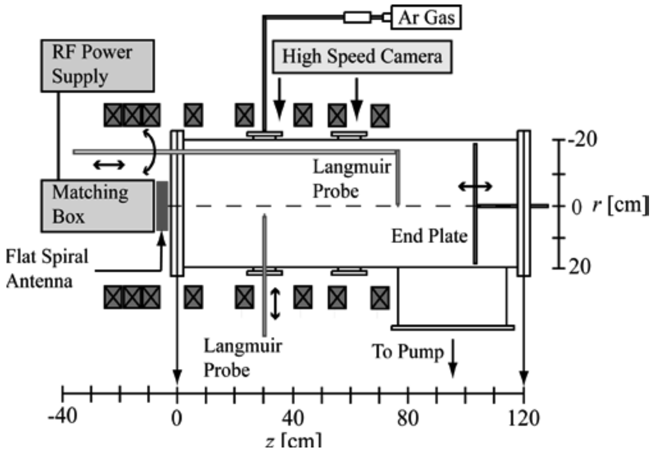

Fig. 1. Schematic view of the experimental device.

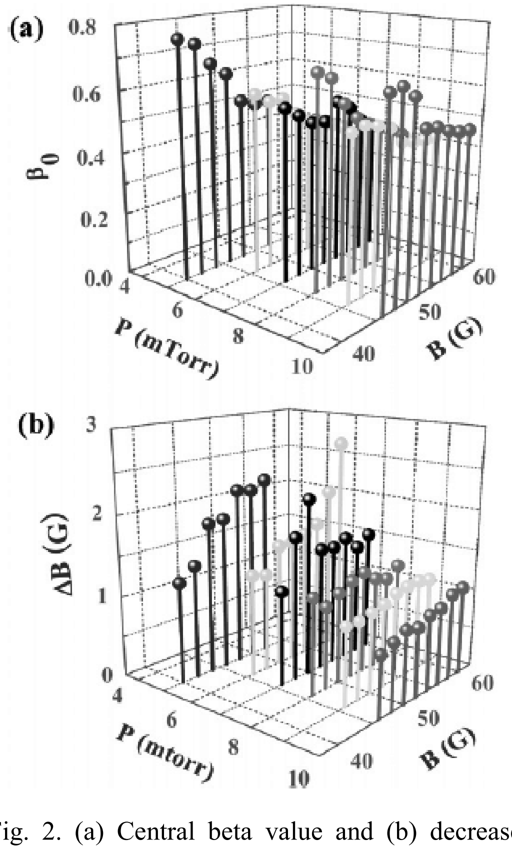

Fig. 2. (a) Central beta value and (b) decrease of the magnetic field in (P, B) space.