§17. Study on Production of Ultra High-Beta Plasma by High-Density Helicon Plasma

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High beta plasma is very important in the fields of space and nuclear fusion, and structural formation associated with various instabilities is also attractive. Here, beta β is the ratio of the plasma pressure to the magnetic field (w/o plasma) one. In NIFS, a plasma with $\beta \sim 5$ % was attained using LHD, and studies on the improved confinement and instabilities are crucial in order to have a higher beta value. Here, in this study, we will try to produce ultra high-beta plasmas close to one, using helicon[1] or rf methods, which accept flexible operation, under the low magnetic field.

High density plasmas were obtained with a large diameter such as LMD[2] and LHPD[3] by the use spiral antennas[1-4] with an input rf power of up to 5 kW with an excitation frequency of 3-15 MHz. Here, a neutral pressure effect and MHD approximation[4] were considered, and electron density and its temperature were measured by Langmuir probes and the magnetic field by Hall probes.

Figure 1 shows field reduction ratio $|\Delta B|/B_0$ and β as a function of B_0 (axial magnetic field w/o plasma) in LMD. Here, a field reduction ratio was close to the following formula, including a neutral pressure effect[5]: $R_{II} = 1-\sqrt{1-\beta-\Delta\beta_n}$ ($\Delta\beta_n$ is a ratio of neutral pressure change between w/ and w/o plasmas to the magnetic pressure w/o plasma). Note that in the case of fully ionized plasmas $R_I = 1-\sqrt{1-\beta}$ can be expected from the total pressure balance.

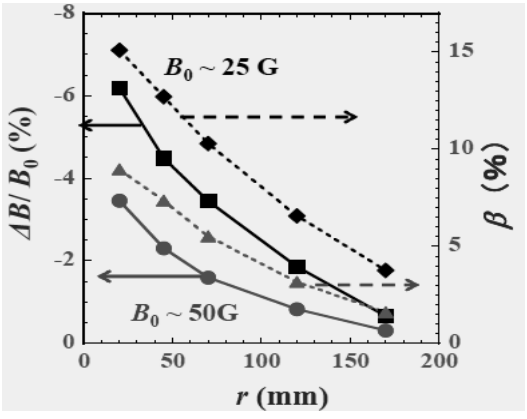

Fig. 1. Radial profiles of field reduction ratio and beta for two magnetic fields (LMD).

As shown in Figs. 2 and 3, using LHPD, we could have the followings: β was close 450 % under the very low field and up to 16 % reduction of the field was found. Results were also consistent with the above formula of R_{II}.

In conclusion, we have succeeded in the very high β of 450 % and up to 16 % field reduction ratio, which can be interpreted using a neutral pressure effect. We will further study the instabilities after producing and characterizing high beta plasmas to have common understandings in fusion fields.

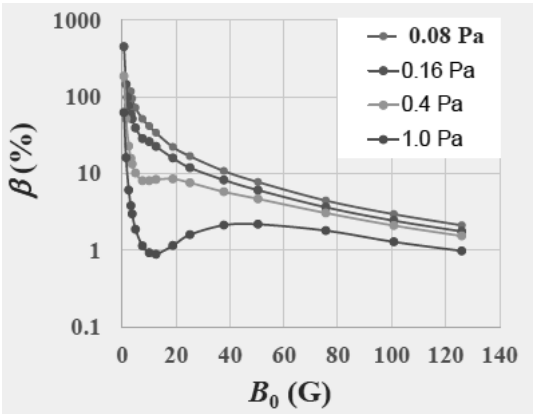

Fig. 2. Dependence of β on magnetic field, changing fill pressure (LHPD).

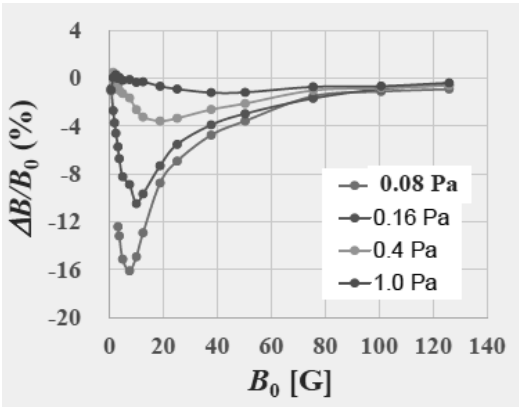

Fig. 3. Dependence of field reduction ratio on magnetic field, changing fill pressure (LHPD).

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