A helicon plasma is high density (~10^{13} \text{ cm}^{-3}) and high ionization ratio plasma, which is produced by a radio frequency (rf) wave in a wide range of external control parameters. Therefore, the helicon plasma is promising for many application fields. For example, in order to develop a long lifetime electric thruster, the helicon plasma is used as a source dense plasma [1].

Helicon plasma can generate a high-beta plasma because it can produce a high-density plasma even in the low magnetic field. Here, this beta “β” is a ratio of the particle pressure to the external magnetic field pressure. The high-beta plasma exclude the external magnetic field from the interior of the plasma to the outside region by inducing an azimuthal current \( j_0 \) (diamagnetism). The decrease of magnetic field, depression ratio, is shown by \( \Delta B/B_0 = 1 - \sqrt{1 - \beta} \) from the total pressure balance. Here, \( \Delta B \) is a change of the magnetic field and \( B_0 \) is the vacuum field without a plasma. Note that this equation does not include the effect of a neutral-gas pressure.

Here, a high-density and high-beta plasma shows various interesting performances of a strong diamagnetism and associated instabilities in the space and nuclear fusion fields. However, a relationship between the diamagnetism and plasma parameter including an operating pressure have not been fully clarified [2]. Therefore, this study aims to study these characteristics using the Large Helicon Plasma Device (LHPD) in ISAS (Fig. 1) [3].

Figure 2 shows \( \beta \) and \( \Delta B/B_0 \) from the measured electron density, its temperature and the magnetic field as function of \( B_0 \). The behavior of \( \Delta B/B_0 \) and \( 1 - \sqrt{1 - \beta} \) are similar, and the beta was increased up to 115%. For a magnetic field of 0.8 G and argon pressure of 0.16 Pa, the maximum beta was ~ 450% near the plasma center. In the presentation, more details of experimental setup and results will be shown.

References