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Effect of Local Helical Coil Field on Vertical Position Displacement Caused by Uniform Horizontal Field in TOKASTAR-2

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The vertical position of the tokamak plasma is considered to be stabilized by the application of a helical magnetic field. In a previous study, we succeeded in stabilizing the vertical position instability in an elongated plasma by using two local helical coils (ULT coils), at the top and the other two at the bottom of the plasma in TOKASTAR-2. The SC coils, which are used to generate elongated plasma, and the ULT coils, are shown in Fig 1. Comparing the horizontal component of the effective magnetic field from the local helical coils and the horizontal component of the two-dimensional magnetic field (quadrupole magnetic field) that makes the elongated plasma, it was confirmed that the position instability tends to be stabilized when the former is larger than the latter, but the boundary between the stability and instability remains unclear [1]. The horizontal component of the quadrupole magnetic field is dependent on the vertical position of the plasma, and its evaluation is affected by the accuracy of the analysis of the vertical position and the reproducibility of the discharge.

In this study, the SC coils are connected in the opposite directions to generate a nearly uniform horizontal field. In addition, by reducing the number of turns of the winding used, the inductance is reduced, and a rapid horizontal field can be applied in response to the time variation of the plasma current. With the change in the SC coil connection, the filament method code that calculates the and the shape of the plasma was modified to allow the direction of the SC coil current to be variable.

A uniform horizontal magnetic field was applied during the discharge to investigate how the response of the plasma vertical position to the uniform horizontal field depends on the presence and magnitude of the local helical coil field.

First, an experiment was conducted to investigate the effect of a uniform horizontal magnetic field under conditions where no local helical coil field was applied. When the charging voltage of the SC coil capacitor was increased, a downward vertical displacement event (VDE) occurred at a peak current value of about 1.1 kAT. Then, the ULT coil field was applied. Its magnitude was nearly constant during the tokamak discharge. The results are shown in Fig. 2. When the ULT coil current was 1.8 kAT, the speed of vertical displacement was reduced and the plasma current duration was increased; when the ULT coil current was 3.6 kAT, VDE did not occur and the plasma current duration was increased to about 0.5 ms. No change was observed when the ULT coil current was increased further to 4.8 kAT.

Visible light images of the plasma were then taken using a high-speed camera. The image was compared with the shape of the plasma obtained by the filament method code. They approximately agreed confirming the validity of the filament method code calculation.

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References

[1] K. Yasuda, T. Fujita, A. Okamoto, et al, Physics of Plasmas, 28 (2021) 082108.

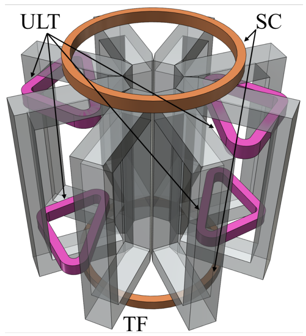

Figure 1 ULT and SC coils

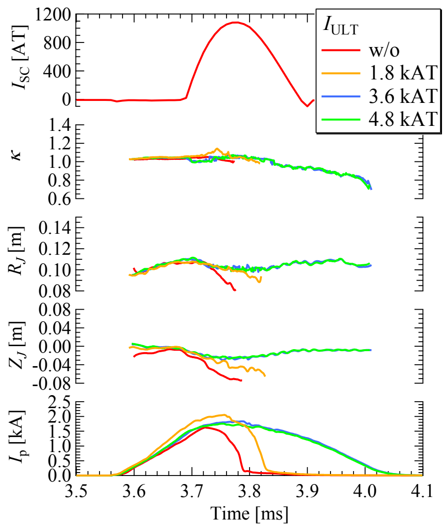

Figure 2 Time evolution of SC coil current, ellipticity, plasma R position, plasma Z position, plasma current of discharges with and without ULT coil field