1P076

小型トカマクPHiXにおける反磁性計測
Diamagnetic flux measurement on PHiX small tokamak

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The plasma stored energy, which is the thermal energy held by plasma, is an important plasma parameter that guides the confinement performance on fusion reactors. In tokamak reactors, diagnostics using diamagnetic loop coils is known as a method to obtain the stored energy.

The diamagnetic current is measured with diamagnetic loops installed in the vacuum vessel. The diamagnetic flux is measured as the integral of the diamagnetic current, and the stored energy can be obtained from the diamagnetic flux.

In this study, we measured the diamagnetic flux in a small tokamak PHiX and evaluate the plasma stored energy.

We installed two diamagnetic loops DL1 and DL2 along the limiter with extension plate, which was fixed on the same plane of the limiter.
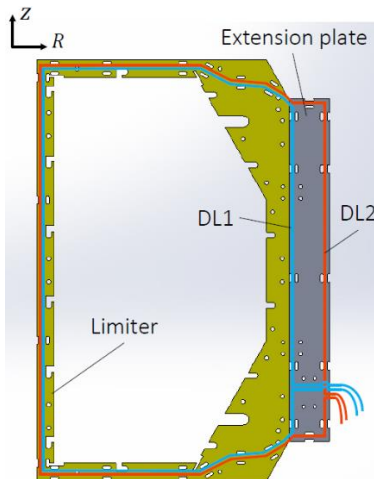

Fig.1   Two diamagnetic loops DL1(blue) and DL2(red) on the limiter with extension plate(grey). DL1 is inside loop and DL2 is outside loop.

Magnetic fluxes ϕ_{DL1} and ϕ_{DL2} are respectively measured as the integral of voltages V_{DL1} and V_{DL2} by DL1 and DL2. Then we obtain net diamagnetic signal $\delta\phi$ using the following formula,

$$\delta\phi = -\frac{1}{k-1}(k\phi_{\mathrm{DL2}} - \phi_{\mathrm{DL1}}) \qquad (1)$$

where k is a constant to remove the contribution from vacuum toroidal field. We find k where $k\phi_{\mathrm{DL2}} - \phi_{\mathrm{DL1}} = 0$ before plasma discharge, then apply (1) to signals ϕ_{DL1} and ϕ_{DL2} after plasma discharge.

Substituting $\delta\phi$ into (2), we get plasma stored energy W_{p}:

$$W_{\mathrm{p}} = \frac{3}{2}V\overline{B_{\mathrm{p}}}^{2}/2\mu_0 - 3\pi R_0 B_{\mathrm{t0}}\delta\phi/\mu_0 \qquad (2)$$

where μ_0 is vacuum permeability, V is plasma volume, $\overline{B_{\mathrm{p}}}$ is linear averaged poloidal field, R_0 is coordinate reference, and B_{t0} is toroidal field at R_0. Figure 2 shows the results of diamagnetic measurement experiment. 250 Hz switching noise signal, which caused by toroidal field coil(TFC), was seen before turned on poloidal field coil(PFC).
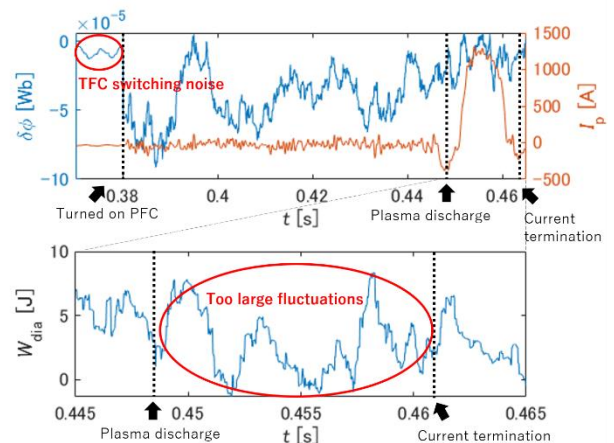

Fig.2   Time evolution of net diamagnetic signal with plasma current(above) and plasma stored energy(below)

For future work, we have to identify and reduce the noises and re-experiment with reduced noises.