§27. Estimation of Island Width by Magnetic Diagnostics in LHD

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It is worthwhile to investigate the behaviour and characteristics of the magnetic island because the magnetic island plays an important role in MHD stability and plasma confinement. In LHD, generally, the width of magnetic island, \( w \), is indicated by the flattening of the electron temperature profile measured by Thomson scattering, which only can be obtained at one toroidal position and therefore gives limited knowledge of the structure of the island. The width \( w \) is related to the perturbed field \( [l] \) as

\[
w^2 = C_0 + \frac{b_1}{B_t}
\]

Here \( C_0, b_1 \) and \( B_t \) are a constant value, perturbed field during the plasma discharge, perturbed field producing the vacuum island and the toroidal field, respectively. For \( b_1 = 0 \) and \( b_0 \neq 0 \), the width \( w \) is equal to that of the vacuum island \( (w = w_{\text{vac}}) \). The magnetic diagnostics measuring the profile of \( b_1 \) is an effective method to find the structure of the magnetic island. The array of the flux loops detects the profile of the field \( \tilde{b}_1 \) originating from the island motion. The component of \( \tilde{b}_1 \) is in the major radial direction. The toroidal profile of \( \tilde{b}_1 \) with the toroidal mode \( n=1 \) indicates that the change of the magnetic island width during a discharge also has the \( n=1 \) mode component. The amplitude \( \tilde{b}_1^{n=1} \) estimates the width \( w \) by using Eq (1) that can be rewritten as

\[
w = \sqrt{\frac{\tilde{b}_1^{n=1}}{B_t} + w_{\text{vac}}^2}
\]

Here \( \tilde{b}_1^{n=1} \) is the maximum amplitude as shown in Fig.1. The calibration between \( w^2 - w_{\text{vac}}^2 \) and \( \tilde{b}_1^{n=1}/B_t \) provides the coefficient \( \alpha \) for the island enlargement cases \( (w \geq w_{\text{vac}}) \) as shown in Fig.2. As a result, the magnetic diagnostics can estimate the island width \( w_{\text{mag}} \). Figure 3 shows the relationship between \( w \) and \( w_{\text{mag}} \). These results show that the magnetic diagnostics can estimate the structure of an magnetic island.

References