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## ITERにおける電流分布計測の総合性能評価に関する研究
## Comprehensive assessment of current profile measurement on ITER

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In ITER, the poloidal polarimeter and motional Stark effect (MSE) diagnostic based on the heating neutral beam (HNB) are classified as primary diagnostics for the measurement of the current profile (safety factor, *q*, profile). The measurement requirements (MR) for *q* have been defined in ITER Project Requirements [1]; the required accuracy of *q*-value is 10 % and the required radial position accuracy of $q$=1.5, 2.0 and $q_{\min}$ is 50 mm. Previous studies [2,3] carried out assessment of the current profile measurement by using either the poloidal polarimeter or MSE at the start-of-burn (SOB) phase. In this study, CUPID (Current Profile Identification) code [2] is applied to assess the accuracy of the current profile measurement under the various conditions; *q* profile measurement with/without error of auxiliary data, *q* profile measurement utilizing both the poloidal polarimeter and MSE, *q* profile measurement utilizing the tilted HNB, *q* profile measurement in the case of plasma with current-hole configuration, and *q* profile measurement during the start-up phase [4].

CUPID determines a current profile consistent with the measurement data from the poloidal polarimeter, MSE, the position and shape of LCFS (*A*), the total plasma current ($I_p$) and the electron density ($n_e$) and temperature ($T_e$) measured by Thomson scattering. We added random errors to the input data, ran CUPID 100 times and evaluated the maximum error of *q* (assessment method discussed in [4]). In the case of *A*, $I_p$, $n_e$ and $T_e$, random errors were added in compliance with MR [1]. The measurement data of the poloidal polarimeter are orientation, $\theta$, and ellipticity angle, $\varepsilon$, of the polarization state of the probe laser beam. The value of $\theta$ and $\varepsilon$ mainly corresponds to the Faraday and Cotton-Mouton effect, respectively. The measurement data of MSE is pitch angle, $\gamma$. We estimate the maximum error of *q*-identification with varying standard deviation of $\theta$, $\varepsilon$, and $\gamma$ ($\sigma_\theta$, $\sigma_\varepsilon$, and $\sigma_\gamma$) and with on/off-axis HNB. The value of $\sigma_\varepsilon$ was pegged at 6 times that of $\sigma_\theta$ in this study (for the reason discussed in [2]).

Fig. 1 is one example of our comprehensive assessments and shows maximum errors of *q*-profile measurements utilizing only poloidal polarimeter as a function of $\sigma_\theta$ at the SOB of ITER S2 (inductive) and S4 (steady-state) operation scenarios. Open symbols denote the reconstructions that only include error related to PoPola data; filled symbols denote the reconstruction that also includes the auxiliary data (*A*, $I_p$, $n_e$ and $T_e$). The errors for S4 are larger than for S2, so S4 establishes the more severe test of the system. Nonetheless, as long as the measurement error of the Polarimeter is less than ~0.4° the polarimeter is able to meet or exceed MR. Errors from the externally supplied data contribute between 10% and 30% to the overall error. This shrinks the allowable error budget for the PoPola system to $\sigma_\theta$ < ~0.1°.

The results under the various conditions suggested that at least one of $\sigma_\theta$ or $\sigma_\gamma$ with 0.1° or less was needed to satisfy the required accuracy of *q* (10 %), and that the influence of the off-axis HNB for the *q*-profile measurement was small. The value of 0.1° is feasible, based on the results of polarimeteries and MSEs in existing tokamaks.

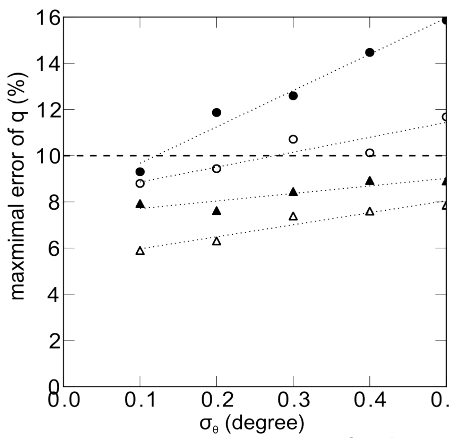


*FIGURE 1. Maximum errors of the q-profile measurement utilizing only poloidal polarimeter as a function of $\sigma_\theta$ at the SOB of ITER S2 and S4 scenarios. (⊿: S2, ○: S4, Filled mark: All input data include error, Open mark: Only PoPola data include error)*

[1] G. Vayakis, et al., Proceedings of the 24th IAEA Fusion Energy Conference, ITR/P5-37.
[2] R. Imazawa et al., Nucl. Fusion **51**, 113022 (2011).
[3] E. L. Foley et al., Rev. Sci. Instrum. **79**, 10F521 (2008).
[4] R. Imazawa, et al., Proceedings of the 24th IAEA Fusion Energy Conference, ITR/P5-38.

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