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ヘリオトロンJにおけるECCDを用いた高エネルギーイオン駆動不安定性の抑制
Suppression of Energetic-Ion-Driven Instabilities by ECCD in Heliotron J

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Energetic alpha particles produced through deuterium-tritium fusion process and beam ions used for plasma heating, which have a velocity comparable with the Alfvén velocity, can interact resonantly with shear Alfvén waves during slowing-down process, and excite energetic-ion-driven MHD instabilities, resulting in enhanced radial transport of the energetic ions. While much attention is focused on gaining a predictive capability for the instabilities through modeling and extrapolation of current experimental results, less attention has been paid to suppression and control techniques. Electron cyclotron current drive (ECCD) is an ideal tool for stabilizing them since it can provide highly localized EC current with a known location and good controllability.

ECCD experiments have been conducted for stabilization of energetic-ion-driven MHD modes in the medium-sized heliotron/stellarator device, Heliotron J. External current of a few kA is driven in the core region, which is externally controlled by parallel refractive index $N_{||}$ of injected EC waves [1]. The EC current modifies the rotational transform profile from a shearless flat one into a high-shear one, as illustrated in Fig. 1. Experimental results show that the energetic-ion-driven MHD modes have been fully stabilized in NBI plasmas by second harmonic 70-GHz X-mode ECCD [2]. In the magnetic configuration of $\iota/2\pi = 0.512$ and 0.525, an MHD mode of 80 kHz is stabilized by the counter-ECCD which forms a positive magnetic shear. Since the mode is excited locally at *r/a*~0.6, the change in the local magnetic shear contributes to the mode stabilization. Figure 2 shows that the mode is stabilized when the magnetic shear exceeds a critical threshold. In the magnetic configuration of $\iota/2\pi$=0.56, other MHD modes of 90 kHz and 140 kHz have been stabilized by co-ECCD which forms a negative magnetic shear in the core region. These experimental results indicate that both co- and counter-ECCD are effective for stabilization of energetic-ion-driven instabilities.

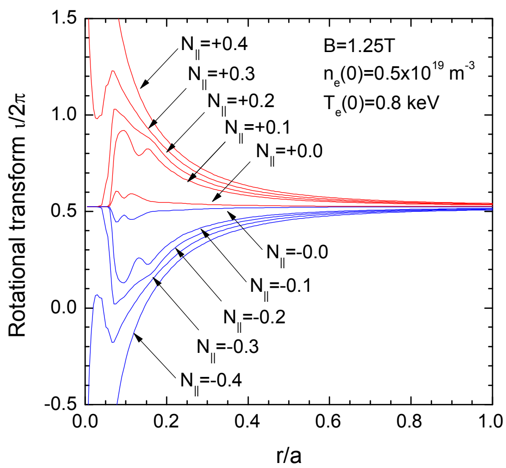

Fig. 1 Rotational transform profile with ECCD in Heliotron J.

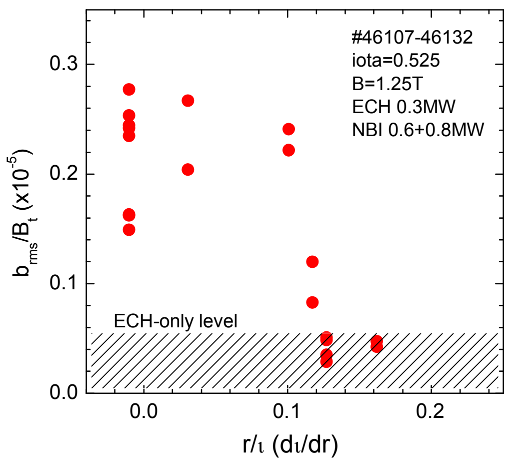

Fig. 2 Magnetic shear dependence of AE mode amplitude in counter-ECCD stabilization.

[1] K. Nagasaki, et al., Nucl. Fusion **51** (2011) 103035
[2] K. Nagasaki, et al., 24th IAEA Fusion Energy Conference, San Diego, 2012, EX/P8-10