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Current Profile Evolutions with External Current Drive for KSTAR

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The current profile evolutions have been measured from the plasma discharges with the electron cyclotron current drive (ECCD) for the Korea Superconducting Tokamak Advanced Research (KSTAR) for the first time. This measurement has been possible by the newly-installed motional Stark effect (MSE) diagnostic system that utilizes the polarized Balmer-alpha emission from the energetic neutral deuterium atoms induced by the Stark effect under the Lorentz electric field. The 25-channel KSTAR MSE diagnostic is based on the conventional photoelastic modulator (PEM) approach with the spatial and temporal resolutions of < 2 cm (for the most of the channels except 2 to 3 channels inside the magnetic axis) and about 10 msec, respectively. The strong Faraday rotation imposed on the optical elements in the diagnostic system is calibrated out from a separate and well-designed polarization measurement procedure using an in-vessel reference polarizer during the toroidal-field ramp-up phase before the plasma experiment starts. The evolution of the pitch angle along with the modulated injection of the 170 GHz ECCD implies that the modulation frequency in the electron cyclotron wave injection is fast compared with the current relaxation time (about 1 sec) at the KSTAR plasmas. According to the magnetic pitch angle profiles, it is conjectured that the wave energy is transported to the plasma with the time scale comparable to that of the modulation (about 0.1 sec). The current density profile that can be inferred from the spatial gradient of the tokamak pitch angle is not drastically changed and instead, a significant shift of the whole profile including the location of the magnetic axis is clearly seen as a result of the energy transport. The measured pitch angle data can be used to constrain iterative equilibrium calculations in order to obtain current density and safety factor profiles consistent with the magnetic flux surfaces.

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