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Impact of the LHD peripheral region and the magnetic axis shift on optimal on-axis ECRH injection for high-electron-temperature plasmas

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The central electron temperature of high-ion-temperature plasmas was successfully increased in the large helical device (LHD) up to 7.6 keV for the central ion temperature of 6 keV and a central electron density of 1.4 x 10ˆ(19) mˆ(-3) by adding a new 154-GHz gyrotron and also by optimization of the ECRH (electron cyclotron resonance heating) injection. The optimization was carried out using the ray-tracing code "LHDGauss," upgraded to include three new features: 1) rapid post-processing 3D equilibrium mapping, 2) refraction of rays in the peripheral region with the finite density gradient outside of the last closed flux surface, and 3) calculations of the ordinary/extraordinary (O/X) mode ratio. The absolute value of the power deposition profiles calculated at every shot enables feedback of the injection condition for the required deposition profile on a shot-by-shot basis, which resulted in the achievement of the high-temperature plasma. The impact of a plasma peripheral region not only on refraction of rays but also on pure excitation of the O/X mode is a common characteristic in magnetically confined plasmas with comparable scale lengths for the density and the magnetic shear angle, e.g., the stochastic region of LHD plasmas, or tokamak pedestal/SOL (scrape-off-layer) plasmas. The adjustment of the ECRH injection settings using the ray-tracing code integrating the LHD peripheral region in 3D equilibrium mapping has contributed to the successful extension of the LHD operational regime.

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