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Experimental and simulation study of error field penetration on EAST

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In the EAST tokamak, density scaling of n=1 error field penetration has been investigated under auxiliary heated discharges. It is found that the density scaling of resonant magnetic perturbation coil current threshold is about $b_r \infty n_e^{0.4}$, where b_r represents the error field amplitude and n_e measured by hydrogen cyanide (HCN) is the line averaged electron density. The results show a weaker density dependence compared to previous ohmic discharge ($b_r \infty n_e^{0.5}$). For better understanding the density scaling, we convert the key discharges parameters into theoretical penetration region, and infer the error field penetration lies in Waelbroeck regime. The observed scaling is consistent with the estimated theoretical result by taking into account the density determination with electron temperature, viscosity diffusion time and plasma mode frequency in experiments. The fitted linear curve obtained by scanning heating power can also give the expression about $[b_r/B_T]_{crit} \sim n_e^{(7/16)} \tau_v^{(-7/16)} T_e^{(9/32)} f_0^{(5/8)}$(Waelbroeck regime).

Considering the heating effect of Lower hybrid wave (LHW) depends on electron density, the strong relationship $T_e \infty n_e^{(-0.65)}$ results in weaker density scaling in auxiliary heated experiments. Using the discharges parameter under auxiliary and ohmic heated as input respectively, the numerical scaling based on reduced four-field two-fluid model agrees well with magnetohydrodynamic (MHD) penetration theory by considering the relationship of multiple parameters on density. In view of electron diamagnetic flow ($f_{(e)}$)*, the theory is still valid. In fact, the mode frequency f_0 based MHD scaling can be replaced by* $f_{(E\times B)}+f_{(e)}$. In L-mode confinement (low β_n), MHD theory of error penetration enough to explain the experimental scaling.

Affiliation

Dalian University of Technology

Country or International Organization

China

Primary author: Prof. WANG, Zheng-Xiong (Dalian University of Technology, Dalian 116024, People's Republic of China)

Co-authors: Mr YE, Cheng (Dalian University of Technology, Dalian 116024, People's Republic of China); Dr SUN, Youwen (Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, People's Republic of China); Dr WANG, Huihui (Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, People's Republic of China); Dr WEI, Lai (Dalian University of Technology, Dalian 116024, People's Republic of China)

Presenter: Prof. WANG, Zheng-Xiong (Dalian University of Technology, Dalian 116024, People's Republic of China)

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