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LOWER HYBRID CURRENT DRIVE EFFICIENCY IN THE PRESENCE OF TRAPPED ELECTRONS *)

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The Lower Hybrid current drive in the presence of the trapped electrons has been analysed by solving relativistic 2D bounce-averaged Fokker-Planck equation [1]. Conditions typical of small aspect ratio of a/R0=2.2 tokamak T-15MD have been modelled. A process of current drive has been simulated using the coefficient of quasi-linear diffusion D_{ql} and the slowing down spectrum of the LH waves that are consistent with the results of the modelling obtained with FRTC code [2,3]. The toroidal electric field was absent in the present work. Dependence of the current drive efficiency $\eta=J_{lhn}/P_{lhn}$ on parameter $\varepsilon=r/R_0$, has been analysed, where $J_{lhn}=J_{lh}/\nu v_{te}^2$, $P_{lhn}=P_{lh}/\nu v_{te}^2$, r, R0, ν and v_{te} are the normalised current density, absorbed LH power density, minor, major radii of the magnetic surface, electron collision frequency and thermal velocity, respectively. The ε parameter varied in the range of 0÷0.3 in accordance with the localisation of the LH driven current as shown via FRTC modelling [2,3]. Dependences of current drive efficiency on the input LH power and effective plasma charge Z_{eff} have been tested.

The absorbed LH power depends on the electron temperature T_e, density n_e, coefficient of quasi-linear diffusion D_{ql} and slowing down spectrum of the LH waves. T_e=1keV and n_e=1.5cm^{-3} were chosen in the modelling as parameters relevant to current ramp up phase in the T-15MD tokamak. The longitudinal phase velocity of the waves was in the range $3.5<\omega/k_{//}v_{te}<9.5$, where ω is the wave frequency, $k_{//}$ wave vector projection on the magnetic field. The amplitude of the D_{ql} defines the absorbed power density of the waves. The current drive efficiency η decreases by factor of 2 with increase of the ε from 0 to 0.3 for $D_{ql}/\nu v_{te}^2=1$, corresponding to the total absorbed power close to 0.5MW. The trapped electron population rises with increase of the ε. Trapped electrons absorb LH power, but do not contribute to the plasma current and this fact explains the decrease in the η. The time required to reach a steady state is longer by factor of 2 at $\varepsilon=0$ compared to $\varepsilon=0.3$.

A population of the passing electrons in the tail of the distribution function grows with increase of the absorbed LH power for larger $\varepsilon\approx0.3$. These electrons populate the trapped particle part in the distribution function due to pitch angle scattering. Fast trapped electrons can absorb LH power, but do not contribute to the generated current. The modelling shows that current drive efficiency η decreases from 14 to 4 with the increase in the absorbed power from 0.5MW to 4MW. Such increase in the modelling is achieved by variation of the normalised quasi-linear diffusion coefficient D_{qln} from 1 to 100. The time required to reach a steady state regime increases from 10ms at absorbed LH power of 0.5MW to 70ms at the power of 4MW. An absorption of the power by fast trapped particles predominantly at high level of P_{lh} causes a transition from a regime of current drive to a regime of the peripheral electron heating.

The dependence of the current drive efficiency η on the plasma effective charge Z_{eff} has been verified in the absence of the toroidal electric field. The modelling is in the agreement with the analytical prediction [4] of $\eta\sim1/(Zeff+5)$.

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