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Lower hybrid current drive at high density in the multi-pass regime[1]

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Assessing the performance of lower hybrid current drive (LHCD) at high n_e is critical for developing non-inductive current drive systems on ITER and future steady-state experiments. Excellent LHCD efficiency has been observed during fully non-inductive operation at moderate n_e (η = 2.0-2.5x10^{19} $AW^{-1}m^{-2}$ at n_e = 0.5x10^{20} m^{-3}) on Alcator C-Mod under conditions (n_e, magnetic field and topology, LHCD frequency) relevant to ITER. To extend these results to advanced tokamak regimes with higher bootstrap current fractions on C-Mod, it is necessary to increase n_e to 1.0-1.5x10^{20} m^{-3}. However, the number of current-carrying, non-thermal electrons generated by LHCD drops sharply in diverted configurations at densities that are well below the density limit previously observed on limited tokamaks. In these cases, increased SOL currents and changes in edge ionization and density profiles are observed during LHCD, indicating that significant power is transferred from the LH waves to the SOL. Fokker-Planck simulations of these discharges utilizing ray tracing and full-wave propagation codes indicate that LH waves in the high n_e, multi-pass absorption regime pass through the SOL several times, where parasitic losses can play a significant role in the loss of current drive efficiency. Modeling predicts that LHCD efficiency increases with stronger single-pass absorption, independent of the loss mechanism in the edge and SOL. Experimental data show that increasing T_e in high n_e LH discharges results in higher non-thermal electron emission, as predicted by the models. Recent developments in simulation codes have expanded our understanding of the mechanisms involved in reducing current drive efficiency at high density, thereby enhancing our capability to predict the performance of LHCD for future fusion facilities.

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