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High Density LHRF Experiments in Alcator C-Mod and Implications for Reactor Scale Devices

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Parametric Decay Instabilities (PDI) have been linked to the sudden loss of superthermal electrons and current drive efficiency as the density is increased above a critical density n_crit in lower hybrid current drive experiments in Alcator C-Mod. Spectral peaks occur at multiples of the ion cyclotron frequency near the inner wall. As the density is increased to n_crit, the sidebands become strong with energy content comparable to that in the spectrum around f_0 and pump depletion sets in. The onset and character of the PDI are consistent with solutions of the PDI dispersion relation ϵϵ_1+(1+χ_i)χ_e μ^2=0 where the coupling constant μ^2 depends linearly on the square of the parallel and perpendicular components of the pump electric field. The results show that the observed PDI are associated with excitation of ion cyclotron quasi-modes (ω≈nω_ci) which are found to be dominant over ion sound quasi-modes (ω≈k_∥v_ti). In both experiment and calculation strong excitation occurs for ωω_LH⊠4. Even with n≈n_crit, the data show that the pump propagates to the inner wall with modest attenuation. This implies that the absorption of the pump is weak during the first pass from the LH antenna to the inner wall and suggests that stronger first-pass absorption should restore the current drive efficiency observed at lower density. Operating at higher T_e and locating the launcher off mid-plane can improve single pass absorption. An off-midplane "bi-junction"launcher has been designed for C-Mod and is planned to be installed in the near future. When combined with the present mid-plane launcher the total available power will be increased from 1 to 2 MW. Simulations indicate that even with full absorption of the pump at the inner wall, e.g. by PDI, ~ 150 kA can be driven at n = 1.4 x 10^20 m-3.Injecting LH power into higher density H-mode plasmas has a profound effect on the edge and SOL turbulence, decreasing the density-fluctuation power significantly. In many of these discharges, increases in confinement are observed after the LH power is applied. In this case strong PDI occur at the cyclotron frequency and harmonics corresponding to the field near the launcher. Application of LHCD to reactor scale devices will be discussed, including advantages of launching from the inner wall.

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