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Pressure-Gradient-Limiting Instability Dynamics in the H-mode Pedestal on DIII-D[1]

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Detailed 2D measurements of long-wavelength density fluctuations in the pedestal region with beam emission spectroscopy during the inter-ELM phase indicate two distinct bands of fluctuations propagating in opposite poloidal directions in the plasma frame: one lower frequency band (20-150 kHz) advects in the ion-diamagnetic drift direction (ion mode), and a higher frequency band (200-400 kHz) advects in the electron diamagnetic drift direction (electron mode). Interestingly, the mode amplitudes are modulated with the ELM cycle with the ion mode having some features qualitatively similar to those predicted for kinetic ballooning modes (KBM). Experiments have focused on determining the role of current and pressure gradient-driven instabilities in determining the H-mode pedestal structure. Detailed analysis of the temporal evolution reveals complex dynamics. The ion mode amplitude increases rapidly after an ELM and then saturates, consistent with the dynamics of the pedestal electron pressure, while the electron mode is quasi-stationary between ELMs. The decorrelation time of the ion mode is $<5\,\mu$s ($\tau_c \times c_s/a \leq 1$), the radial correlation length is of order $10\,\rho_i$ and the poloidal wave-number $k_\theta \rho_i \sim 0.1$. The mode velocity is comparable to the diamagnetic velocity. In related Quiescent H-mode experiments, pedestals with high electron pressure and high $E \times B$ shearing rates exhibit a set of high-frequency coherent modes propagating in the ion diamagnetic direction. These modes also exhibit KBM-like characteristics, but do not develop into fully turbulent structures. Numerical simulations are in progress to help identify the underlying instabilities and nature of these modes, and ultimately help validate nonlinear models of the H-mode pedestal structure.

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