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Fluctuating Zonal Flows in I-mode in Alcator C-Mod[1]

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Velocity fields and density fluctuations of edge turbulence have been studied in I-mode [1] plasmas of Alcator C-Mod, which are characterized by a strong thermal transport barrier in the edge while providing little or no barrier to the transport of both bulk and impurity particles. This allows access to steady state, high performance discharges without explosive edge relaxations or impurity accumulation. The key feature in the I-mode edge seems to be a weakly coherent mode (WCM) at $100 - 300$ kHz, with $\Delta f \approx 150$ kHz and a poloidal wavenumber $k \approx 1.5\,\mathrm{cm}^{-1}$. Although previous work showed no clear geodesic-acoustic modes (GAM) on C-Mod, using a newly implemented, gas-puff-imaging (GPI) based time-delay-estimate (TDE) velocity inference algorithm, GAM are now shown to be ubiquitous in all I-mode discharges, with the time histories of the GAM and the WCM closely following each other through the entire duration of the regime. The central frequency of the WCM is shown to scale with $H_{ITER,98}$, which itself scales with the depth of the radial electric field well in the edge [2]. Thus, the I-mode presents an example of a plasma state in which quasi-static zonal flows (ZF) and GAM continuously coexist. Using both single- (density) and two-field (density-velocity) bispectral methods, the GAM are shown to be coupled to the WCM and to be responsible for its broad frequency structure. Since the WCM activity is strongly correlated to the I-mode behavior [3], and due to the known dependence of the GAM damping on collisionality [4], the decrease in GAM amplitude, and with it WCM activity, at higher densities offers an explanation for the density limit for I-mode access [3].

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