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New Insights into Short-Wavelength, Coherent Edge Fluctuations on Alcator C-Mod

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Two new research tools - a Mirror Langmuir Probe (MLP) and a "Shoelace" antenna - have diagnosed and actively perturbed fluctuations in the Alcator C-Mod tokamak edge plasma. Both tools elucidate the physics associated with the Quasi-Coherent Mode (QCM, k_p~1.5/cm, f~50-200 kHz), the edge fluctuation responsible for the increased particle flux which sustains the steady-state Enhanced Dα H-mode. The MLP has characterized the QCM with unprecedented detail, showing it to be primarily a drift wave, with curvature also playing an important role. In addition, the Shoelace antenna actively probes these fluctuations at a specific k_p (1.5/cm) within a broad (45-300 kHz) frequency range.
The MLP provides electron density (ne), temperature, and potential (Φ) measurements at a ~1 MHz rate, and scans across the scrape-off layer to just inside the last closed flux surface (LCFS). Recent experiments using the MLP to investigate the QCM have placed the mode within a ~3 mm layer which spans the LCFS, in a region of stationary drift where the shear vanishes from the combined diamagnetic and ExB flows. The mode rotates in the electron diamagnetic drift (EDD) direction in both the lab and plasma frames. The probe has revealed that the QCM frequency band is well-described by the drift-wave dispersion relation. Moreover, the MLP has shown that Φ lags ne by ~16 degrees, indicative of drift-wave behavior. MLP and Bp coil measurements also show a significant interchange component in the mode drive.
Complementing this diagnosis of the QCM, the Shoelace antenna drives edge fluctuations directly. Its winding imposes k_p=1.5/cm, matching the QCM, and it is driven at arbitrary frequency from 45-300 kHz, with the capacity to lock in real time to a fluctuation signal. Cross-coherence between the antenna current and fluctuation diagnostics (phase contrast imaging, Mirnov coils, and polarimetry) shows that the antenna produces a coherent Bp excitation throughout the discharge, and a coherent ne response after the transition to H-mode, starting prior to the onset of an intrinsic QCM. The driven mode is roughly field-aligned, with phase velocity pointing in the EDD direction, and is guided by field lines. The response is resonant at the QCM frequency, with a weak damping rate, γ/ω~5-10%. Experiments in 2014 will determine whether the antenna also drives transport like the QCM.

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