Plasma Turbulence in- and outside the LCFS on Alcator C-Mod*

I. Cziegler, A. Dominguez, M. Greenwald, A.E. Hubbard, E.S. Marmar, J.W. Hughes, B. Lipschultz, J.L. Terry, D.G. Whyte

Massachusetts Inst. of Technology - Plasma Science & Fusion Center Cambridge, MA 02139, USA.

Experimental studies of plasmas in various confinement states were carried out in order to characterize the turbulence patterns both in the closed and the open field line regions at the plasma edge and their connection to the quality of global confinement. A combination of density and temperature fluctuations was diagnosed using a high-bandwidth (2 MHz) Gas-Puff-Imaging array extending from ~2 cm inside the separatrix to ~2 cm into the Scrape-Off-Layer on the low-field side midplane.

In the SOL, intermittent, convective transport via filamentary structures (blobs) carries plasma to main-chamber wall surfaces. Due to the high level of intermittency, the spectra are analyzed using wavelet techniques to yield data on motion and characteristic scales. In the far SOL the blobs generally move poloidally in the ion diamagnetic direction and consistent with the E×B direction and magnitude there. In addition to poloidal motion, rapid outward radial motion is observed and compared to current theoretical models [1] predicting various scalings between the radial blob speed and poloidal size. Filament generation is studied through correlation of ejection times with short time-scale changes of the edge region fluctuations. Previous results indicating that the turbulence in the high-gradient edge region and SOL would set the level of fluxes crossing the last-closed flux surface (LCFS) and play a central role in density limit physics [2] are revisited on this basis, and compared to GPI measurements from a scan of operational parameters and plasma regimes. In the SOL the characteristics of the turbulence seem not to depend upon the confinement mode.

This is in sharp contrast to the behavior of the turbulence in the edge region. All regimes produced in Alcator C-Mod were studied, including L-mode, ELM-free H-mode, Enhanced-D-Alpha (EDA) H-mode, ELMing H-mode, and, more recently, an improved L-mode (“I-mode”) [3]; and it was found that all the above confinement states exhibit different edge turbulence characteristics by which they can be clearly identified. In L-mode plasmas the dominant broadband turbulence inside the LCFS propagates poloidally in the electron diamagnetic drift direction. In ELMfree H-mode plasmas, the turbulence propagating in the electron diamagnetic drift direction decreases by over a factor of 10 in power, compared to L-mode, and speeds up to ~25 km/s. In EDA H-mode, steady-state plasma and impurity density profiles are achieved due to the particle transport through the edge pedestal provided by the Quasi-Coherent Mode (QCM). The I-mode has energy confinement significantly better than L-mode ($H_{ITER-98}$ up to 1.2), with a steep edge temperature pedestal, but no build-up of a density pedestal, typically found in H-mode regimes. A key feature of the I-mode is an edge fluctuation at 100–300 kHz, which though exists in the same frequency range, is significantly broader than the QCM of the EDA H-mode. The region in ELMing discharges exhibits precursor oscillations to the ELM crash events. These mode-like plasma responses of high-confinement regimes are all compared with respect to propagation speeds and directions and characteristic scales. They occur with $k_{pol}\rho_s$ in the range 0.10–0.13, similar to the $k_{pol}\rho_s$ values found at a “break-in-slope” of L-mode spectra. All the above emphasize the importance of the closed field region in determining both the structure of the pedestal and the SOL turbulence.

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[2] B. LaBombard et al., Phys. Plasmas **8**, 2107 (2001).
[3] F. Ryter, et al, Plasma Phys. Control. Fusion **40** 725 (1998).

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