Experimental Studies of Turbulence with the Phase Contrast Imaging Diagnostic in the Alcator C-Mod Tokamak *

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The origin and nature of the anomalous electron thermal transport is perhaps the most important unresolved issue in the plasma transport area. In reactor scale fusion devices like ITER, ions and electrons will be closely coupled; thus, thermal transport through the electron channel may dominate. Short wavelength ETG turbulence is possibly an important contributor to the electron thermal transport. To experimentally study the ETG turbulence, the phase contrast imaging (PCI) diagnostic in the Alcator C-Mod has been upgraded extensively. In principle, the enhanced PCI diagnostic is capable of measuring turbulent density fluctuations in the wavenumber (k_R) range of 0.5-55 cm^{-1} and in the frequency range of 2 kHz-5 MHz, thus covering ITG, TEM, and ETG turbulence. Recently, a search for the ETG turbulence has been carried out in the low density ohmic plasmas; we have observed fluctuations with frequency up to 500 kHz and wavenumber up to 20 cm^{-1}, which corresponds to $k_R\rho_s$~1.6. Furthermore, as the density increases in ohmic plasmas, the observed relative density fluctuation level decreases in the "linear" ohmic regime (low density, Alcator scaling, $\tau_{\mathrm{kin}}\propto n_{\mathrm{e}}$), whereas it increases in the "saturated" ohmic regime. Besides investigating the short wavelength ETG, the PCI diagnostic has also been used to study the longer wavelength turbulence in the ITG/TEM regime. A broadband turbulence propagating in the ion diamagnetic direction has been observed, whose frequency range (160-350 kHz) and wavenumber (k_R~5 cm^{-1}, $k_R\rho_s$~0.6) qualitatively agree with the ITG turbulence. We will compare these measurements with gyro-kinetic codes (GS2, GYRO), and results will be reported as available. In addition to the drift-wave type turbulence, we will present the recent results on the edge-localized quasi-coherent (QC) modes. The relative intensity of the QC modes is reduced toward the X-point. Moreover, the spatial location of the intensity reduction moves with the X-point.

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