Study of the Poloidal Variation and Spectral Structure of Short-Wavelength Edge Turbulence using Phase Contrast Imaging on DIII–D*

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The Phase Contrast Imaging (PCI) diagnostic has been used on DIII–D to measure plasma turbulence over the wavenumber range of 2 to 30 cm^{-1} using three different beam paths; vertical through the LCFS at the outboard midplane (edge), 11° from vertical through the outer plasma reaching $r/a = 0.75$ (Phase I), and now vertical reaching $r/a = 0.4$ (Phase II). PCI measures modes propagating perpendicular to the beam path, i.e. $k_\theta \sim k_r$ at the edge in Phase I and II. The Phase II beampath samples the edge plasma symmetrically $\theta \sim \pm 70°$ and the Phase I beampath samples the edge plasma at $\theta \sim +45°$ and $-25°$. An optical filter provides localization of the measurement of ITG/TEM/ETG-driven turbulence. The work presented here focuses on turbulence measurements during QH-mode plasmas with nearly stationary plasma parameters and a quiescent edge.

The comparison of measurements made in the different beampath configurations allows the characterization of the poloidal variation in the edge turbulence and more complete spectral structure than is generally available with PCI. The edge turbulence consists of modes with a single sign in k_θ; i.e. the turbulence propagates in either the electron or ion direction. The turbulence parameters such as amplitude, group velocity V_{gr}, and the power spectrum $S(f)$ are significantly different for $k_{\mathrm{pci}} < 0$ and $k_{\mathrm{pci}} > 0$. The PCI cannot distinguish between up-down ($z < 0$ or $z > 0$) asymmetries in the turbulence vs. spectral asymmetries in radial wavenumber k_r.

One expected cause of asymmetry in the turbulence amplitude is damping near the X-point. Comparison of PCI results from matched LSN and USN QH-mode plasmas suggests that the turbulence is strongly biased toward $k_r < 0$ when $f < 400$ kHz and $k < 6$ cm^{-1}. This lower-k turbulence is unaffected by the X-point, while higher-k turbulence appears damped on the side closer to the X-point.

Variation with poloidal angle near the midplane was studied using a scan in plasma outer gap, which had the effect of scanning the PCI measurement locations to the midplane. As the upper and lower measurements approached each other, any effect of poloidal variation should have disappeared, however the data showed an increasing difference between the turbulence characteristics for $k_r < 0$ and $k_r > 0$. Significant geometric effects near the midplane are not expected; following the magnetic field lines shows that k_{pci} will not change in the measurement region and the perpendicular plasma velocity should vary less than 20%.

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