Comparison of a Synthetic Phase Contrast Imaging Diagnostic with Experimental Measurements

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The Phase Contrast Imaging (PCI) diagnostic is currently used on DIII–D to measure plasma turbulence in the wavenumber range of 2 to 30 cm^{-1} in the outer plasma (typically $r/a > 0.75$). A synthetic diagnostic (SD) has been created to process output from the GYRO gyrokinetic simulation to model the PCI measurement. The SD includes line integration along the full path and the detector geometry to obtain the high-k and low-k cutoffs and has been applied to simulations of DIII–D and Alcator C-Mod plasmas. Modeling of a plasma discharge typical of DIII-D is used to interpret the PCI spectra $S(k_\perp, f)$ in terms of the local $S(k_r, k_\theta, f)$. Initial results show the connection between the modes as measured by the PCI and the underlying instabilities: Turbulence recorded by the PCI away from the midplane with $k_r \sim k_\theta$ is the shear-broadened extension of turbulence driven at the midplane with finite k_θ and $k_r = 0$. A strict correspondence between the observed $k_\perp$ and the original k_θ suggested by simple geometry is precluded by the finite width of the spectral peak. It is also seen that the variation in the shape of the turbulence spectrum along the PCI beampath in the ITG–TEM range leads to a larger contribution from the plasma edges, despite a uniform turbulence amplitude. The SD has allowed us to start to develop a much more sophisticated understanding of the PCI measurement and will also eventually contribute to validation of the model through comparison between the simulation and the experiment.

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