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Numerical Diagnostic to Investigate Poloidal Asymmetry in Three-Dimensional Magnetic Configurations

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Some experimental observations show poloidal asymmetry in the turbulence measurements, which can affect the plasma transport, so detailed spatial structures must be clarified. In Large Helical Device (LHD), an up-down asymmetry has been observed by the PCI diagnostic. Complicated configurations make it difficult to capture the entire structures of fluctuations in helical plasmas, so three-dimensional (3-D) turbulence simulations are necessary for understanding the mechanism. We are developing the Turbulence Diagnostic Simulator (TDS), and carry out the numerical diagnostics in helical plasmas for understanding the plasma turbulence. In this case, the gyrokinetic simulation code GKV-X provides turbulent fluctuations in 3-D configurations, and then, the TDS calculates its line-integration along the line of sight (LS) as in phase contrast imaging (PCI) to give numerical observation signals. There is a problem to resolve the local values from the line-integrated signal. The pitch angle of the magnetic field is used to help the identification of the local spectrum. A finite resolution in the local wavenumber spectrum deteriorates the reconstruction. The ITG modes have a characteristic wavelength and frequency, and difference in the spectrum can be distinguished at different radial positions, considering the spatial resolution. Characteristics of turbulence can be estimated by this analysis. The results of the TDS application indicate three factors to induce the poloidal asymmetry; 3-D magnetic configuration with the realistic LS, effect of signal processing techniques, and inherent inhomogeneity of the turbulence itself. The original data includes only small up-down asymmetry, because this is given from a single flux-tube data. The effect from the 3-D configuration generates the asymmetry, and tends to be enhanced by signal processing, but is not comparable with the experimental results. Artificial reduction of the fluctuation amplitude in the bottom half of the region can give the comparable asymmetry. This result indicates an inherent asymmetry of the turbulence. This asymmetry may be attributed to the dependence on the field line label, which is being confirmed by the GKV-X code.

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