Measurement of the turbulent phase velocity in the L-mode edge of ASDEX Upgrade and comparison with GEMR simulation

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In order to identify the turbulence regime it is important to know the phase velocity \(v_{ph}\) of the underlying instability. Electron drift wave (EDW) is theoretically predicted to govern turbulence in the plasma edge region \((0.95 < \rho_{pol} < 1)\) driven by a strong density gradient \([1]\) present there. The phase velocity of EDW in the linear phase \(v_{ph}(k_\perp) = \frac{v_{de}}{1 + k_\perp^2 \rho_s^2}\) is comparable to electron diamagnetic velocity \(v_{de}\) at low normalized wavenumber \(k_\perp \rho_s \approx 0\), but it is equal to only \(0.3v_{de}\) at \(k_\perp \rho_s = 1.5\) (here \(\rho_s = \sqrt{m_iT_e/eB}\) is the drift wave scale). In experimental study of the dispersion relation of turbulent density fluctuations in the L-mode plasma edge of ASDEX Upgrade, the propagation velocity \(v_\perp = v_{E\times B} + v_{ph}(k_\perp)\), composed of the background ExB drift and the intrinsic phase velocity of the turbulence, has been measured at different perpendicular wavenumbers. The diagnostics used were poloidal correlation reflectometry \((k_\perp = 0–3\ \text{cm}^{-1})\) \([2]\) and Doppler reflectometry with movable mirror \([3]\) (up to \(k_\perp = 15\ \text{cm}^{-1}\)). We show that \(v_\perp\) and hence \(v_{ph}(k_\perp)\) is nearly constant between \(k_\perp = 0\) and \(12\ \text{cm}^{-1}\) \((k_\perp \rho_s = 0–1.3)\). The theoretically suggested dependence on \(k_\perp \rho_s\) is not found. The magnitude of the turbulent phase velocity \(v_{ph}\) in the edge is estimated from the difference of the measured \(v_\perp\) and the neoclassical estimate of the \(E\times B\) velocity \(v_{E\times B}\). The obtained phase velocity \(v_{ph} \lesssim 0.5\ \text{km/s}\) in the electron diamagnetic direction is significantly smaller than EDW prediction \((\approx 4\ \text{km/s at } k_\perp \approx 1\ \text{cm}^{-1})\) for the analyzed discharge. To investigate this difference, nonlinear turbulence simulation has been performed with gyrofluid code GEMR \([4]\). The phase velocity predicted by GEMR is found to be smaller than linear EDW as well. Its dependence on the perpendicular wavenumber has been compared with the measurements. Possible reasons for the discrepancy between experimental values and linear predictions are discussed.

References