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Study of turbulence-induced refraction of Lower Hybrid waves using synthetic SOL blobs

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Ray-tracing/Fokker-Planck (RT/FP) simulations with realistic 3D scrape-off layer (SOL) turbulent density profiles provide evidence of significant RF-turbulence interaction that affects Lower Hybrid current drive (LHCD) in tokamaks. Synthetic SOL turbulence profiles that account for dense field-following blob-like structures are coupled to the RT code GENRAY. Modification of ray-trajectories due to turbulence-induced refraction (TIR) is shown to increase with blob density and decrease with blob width, consistent with previous theories. However, it is found that spatially intermittent density fluctuations lead to increased angular diffusion of the perpendicular wavevector ($k_\perp$) compared to previous models that assume drift-wave-like turbulence. In a modelled Alcator C-Mod discharge, TIR results in significant diffusion of ray-trajectories in phase-space, greatly increasing the robustness of RT/FP models in the multi-pass regime. In C-Mod, TIR also results in smoother current profiles, diminished off-axis current peaks, and increased near-axis current, all of which contribute to better match experiment. The role of $k_\perp$ broadening, due to turbulent scattering, versus broadening of the incident parallel wavenumber ($k_{||}$), due to parametric decay instabilities (PDI), in explaining the spectral gap is also investigated. A previous study reports that ~50% power redistribution of the launched $k_{||}$-spectrum is required to match experimental hard x-ray measurements in C-Mod [Y. Peysson, et al., PPCF 58, 044008 (2016)]. The inclusion of $k_\perp$ broadening from TIR lowers the necessary power redistribution to a more realistic ~10%. Lastly, simulations predict that modification of the current profile due to TIR is mitigated in a DIII-D high-field side single-pass damping scenario, where shorter propagation distances result in decreased ray stochasticity.