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Investigating magnetic fluctuations in tokamak SOL turbulence using gyrokinetic simulations

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Understanding turbulent transport physics in the tokamak edge and scrape-off layer (SOL) is critical to developing a successful fusion reactor. The dynamics in these regions plays a key role in determining the L-H transition, the pedestal height and the heat load to the vessel walls. Large-amplitude fluctuations, magnetic X-point geometry, and plasma interactions with material walls make modeling turbulence in the edge/SOL more challenging than in the core region, requiring specialized gyrokinetic codes. Electromagnetic effects can also be important in the edge/SOL region due to steep pressure gradients and non-adiabatic electron dynamics, which can result in line bending due to coupling of perpendicular dynamics with kinetic shear Alfven waves. However, all gyrokinetic results in the SOL to date have assumed electrostatic dynamics, due in part to numerical challenges like the Ampere cancellation problem. We present the first nonlinear electromagnetic gyrokinetic results of turbulence on open field lines in the tokamak SOL, obtained using the Gkeyll full-f continuum gyrokinetic code. The results, which use a model helical SOL geometry and NSTX-like parameters, show that even strong magnetic turbulence with fluctuations up to $\delta B_\perp/B \sim 1\%$ can be handled robustly. Line-tracing visualizations show that field lines are pushed and bent by radially-propagating blobs. Preliminary comparisons to electrostatic simulations show that including electromagnetic effects can produce larger, more intermittent relative density fluctuations, but somewhat surprisingly, less radial transport in some cases. We also examine how the magnetic geometry influences the importance of electromagnetic effects via the connection length and magnetic shear.