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Flow-shear suppression of anisotropic plasma turbulence

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The performance of magnetic-confinement-fusion devices is often limited by the presence of turbulent fluctuations that lead to enhanced transport and energy losses. Both experimental and numerical investigations have shown that the turbulent fluctuations, and thus the transport properties of magnetised plasma, are influenced by the presence of sheared flows [1, 2, 3, 4]. Such flows can be either externally imposed or internally driven by the plasma itself. Here, we consider the effects of mean perpendicular flow shear on magnetised-plasma turbulence driven by microinstabilities. Assuming a saturated state with well-defined outer (energy-injection) scale and energy cascade [5], we derive scaling laws for the outer-scale wavenumbers and fluctuation amplitudes as functions of the imposed flow shear. In the case of anisotropic, 'streamer-dominated' turbulence, we find that flow shear can lead to significant suppression of turbulent transport at levels much lower than the rate of energy injection (i.e., than the growth rate of microinstabilities). Our theoretical predictions are confirmed by numerical results from both electrostatic gyrokinetic simulations and an electrostatic fluid model [6]. Finally, we discuss the consequences of our results for the cross-scale interactions between ion-scale flows and electron-scale turbulence.

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