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Discoveries From the Exploration of Gyrokinetic Momentum Transport[1]

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Gyrokinetic momentum transport can be driven by a variety of mechanisms that break the parity along the magnetic field: parallel and $E \times B$ velocity shear, parallel velocity, up/down flux surface asymmetry. In this work, the discovery of interesting properties of these mechanisms and a new mechanism will be reported. The first result is that the Kelvin Helmholtz (KH) mode driven by parallel velocity shear can drive a net negative energy flux when the temperature and density gradients are below the threshold for drift-wave instabilities. The signature of a negative ion energy flow from turbulence would be a power balance effective diffusivity that is below the neoclassical ion thermal diffusivity. The second result is the prediction that the effective momentum transport should depend on the relative sign between the toroidal magnetic field and the toroidal rotation. This follows from the relative sign between the $E \times B$ velocity shear in the Doppler shift of the gyro-kinetic equation and the parallel velocity shear term. This is a corollary effect to the property that the toroidal viscous stress can be zero (e.g. for no external torque) even when both the velocity shears are not zero. The two terms try and break the linear mode parity and can cancel each other out giving a net zero stress. A practical solution to the longstanding problem of including $E \times B$ velocity shear in linear driftwave eigenmodes in toroidal geometry has recently been developed for the TGLF gyro-fluid transport model. Simulations of momentum transport with TGLF will be compared with DIII-D data. Finally, when the $E \times B$ velocity is balance by the ion diamagnetic velocity, as in the H-mode edge, it has been discovered that the net stabilizing effect of the $E \times B$ shear is far stronger. The shear in the diamagnetic velocity is yet another symmetry breaking mechanism driving momentum transport.

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