Electromagnetic Turbulence Modification of Neoclassical Transport*

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Abstract

Electromagnetic turbulence affects plasma transport not only through the standard explicit turbulence mechanisms (E×B and magnetic flutter) but through a modification of neoclassical transport. This is because, in the ensemble-averaged drift kinetic equation, quadratic field fluctuation terms appear in addition to the standard equilibrium gradient and average parallel electric field driving terms.

Previously (APS03) we evaluated the parallel current density driven by these quadratic fluctuation terms using results from the GYRO code. We found that the driven current density has positive peaks on low-order rational surfaces, whose widths are a few ion gyroradii, and whose peak values are comparable to or larger than the Ohmic current density, for the DIII-D L-mode plasma which was studied. The peak current densities driven by turbulence were predicted to be much larger than the Ohmic current density in ITER-sized plasmas, assuming gyroBohm scaling of the turbulence.

Expressions for the radial electron energy flux have also been derived. In addition to the standard neoclassical and explicit turbulence terms, {integrals containing $v_{\mathrm{D}}F$ and $\left[\tilde{v}_{\mathrm{E}} + v_{\parallel}\left(\tilde{B}_{\mathrm{x}}/B\right)\right]\tilde{f}$, respectively} and the turbulent ion-electron energy exchange, we find a turbulence-driven modification of the neoclassical energy flux. From our experience with turbulence-driven parallel currents, we expect that, near low order rational surfaces, the new energy flux may be larger than the standard neoclassical energy flux driven by the Ohmic electric field, for the DIII-D parameters considered previously, and should be much larger for ITER parameters. Thus, the new energy transport mechanism may cause fluxes which are comparable to or larger than the standard turbulence driven energy fluxes. Like the turbulence-driven parallel current density, it should be possible to evaluate the new energy flux using results from the GYRO code.

Expressions for the radial flux of toroidal angular momentum have also been derived. These include explicit turbulence driven fluxes, the standard neoclassical flux and a turbulence-driven modification to the neoclassical momentum flux. It should also be possible to evaluate these using results from the GYRO code.

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