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Neoclassical Toroidal Plasma Viscosity with Effects of Finite Banana Width in Finite Aspect Ratio Tokamaks

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Theory for neoclassical toroidal plasma viscosity is to describe the transport processes, including particle, momentum, and energy transport fluxes in real tokamaks with broken symmetry. The predictions of the theory are in agreement with the numerical results in all collisionality regimes in the large aspect ratio limit. The theory has since been extended to finite aspect ratio tokamaks. The extension is made possible because the perturbed distribution function is localized in the phase space in the low collisionality regimes. Thus, the theory can be used to model transport phenomena including toroidal momentum relaxation in real finite aspect ratio tokamaks. However, there are cases where self-consistent magnetic perturbations have radial variations that are comparable to the width of bananas. To model the transport phenomena, the theory for has to be extended further to include the effects of the finite banana width. To that end, an orbit averaged drift kinetic equation has been developed to describe the transport processes in the low collisionality regimes, when the effective collission frequency is much less than the bounce frequency of bananas. The equation is now solved to calculate the neoclassical toroidal plasma viscosity, and, thus, the corresponding transport fluxes through the flux-force relation, to include the effects of finite banana width in various asymptotic limits. The resultant radial profile for the neoclassical toroidal plasma viscosity varies on the equilibrium scale even though the magnetic perturbations vary rapidly. The reason is that the bounce motion of the finite width of the bananas naturally smoothes out the short scale variations. This result is consistent with the experimental measurements.

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