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Weak turbulence transport with background flows using mapping techniques including finite Larmor radius effects

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Electrostatic drift waves produce transport by the E X B motion of a particle guiding center (GC) which can be studied from a Hamiltonian description where the electrostatic potential plays the role of the Hamiltonian. Here, the fluctuating potential is considered to be an infinite spectrum of waves, characteristic of weak turbulence, in two-dimensions. This is studied using a map that presents regular a nd chaotic regions. With an ensemble of particles transport is studied statistically. Finite Larmor radius (FLR) of the particles is include by taking the gyroaverage over one orbit. The main effect is to reduce the wave amplitude that produces a given level of chaos, so fast particles are better confined. The transport is diffusive and the particle distribution functions (PDF) are Gaussian. Then a thermal distribution of Larmor radii was taken which produces the PDFs to become non-Gaussian with long tails while the transport stays diffusive. This behavior is explained theoretically and it is shown that it agrees with the numerical results.

When a sheared flow is included the transport is described by a symplectic mapping when the shear is monotonic. The result is that the poloidal flow has the effect of increasing the poloidal transport so that the variance of the distribution has cubic dependence with time. This super-ballistic scaling means that the particles have an acceleration when the flow is present. This is due to a grow of the particle step size as time increases related to the diffusive spreading in the radial direction. Thus, the waves acting in two dimensions promote particles to take energy from the perpendicular direction of the flow to the parallel direction. The PDF does not deviate much from a Gaussian. Inclusion of FLR effects keeps these results. When there is a thermal distribution of Larmor radii the PDF is no longer Gaussian as in the case without flow. The radial transport is still diffusive but it is enhanced over the values with no flow. The radial transport is still diffusive but it is enhanced over the values with no flow. The self-similarity function is Gaussian for small thermal gyroradius but a long-tailed exponential distribution for large gyroradius. Then, the flow is taken to have non-monotonic radial shear. The map is double-valued and non-twist. The associated transport barriers are studied as well as the FLR effects.

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