Finite orbit width effects on resonant transport regimes of neoclassical toroidal viscous torque within the Hamiltonian approach

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Non-axisymmetric magnetic perturbations caused by external fields from ELM control coils, error fields and toroidal field ripple lead to increased toroidal rotation damping caused by non-ambipolar radial particle fluxes (neoclassical toroidal viscous torque or NTV). At low plasma collisionalities and small enough perturbation amplitudes, quasilinear resonant transport regimes, namely superbanana plateau [1] and resonant plateau regime [2] (bounce/transit and drift resonances) can be dominant for ion NTV, in particular, in ASDEX Upgrade [3]. Within Hamiltonian theory in action-angle variables [4], all those regimes are described in a uniform manner allowing for a physically consistent transition to non-linear regimes [5].

To the lowest order in gyroradius, guiding center orbits are locally bound to a specific flux surface. This approximation is valid to compute canonical (bounce and drift) frequencies as long as the typical spatial scale of the equilibrium field is larger than the radial width of the full orbit. However, the length scale of non-axisymmetric perturbation fields can be of the same order or smaller than the typical orbit width [3]. For this reason, the prediction accuracy can likely be improved by taking the finite orbit width into account, which has recently been considered for superbanana plateau, collisional boundary layer and \(1/\nu\) regime by Shaing and Sabbagh [6].

In this work, a finite orbit width is considered for general resonant transport regimes, also including the resonant plateau by bounce/transit and drift resonances. The Hamiltonian approach is extended to perform integration over drift surfaces. Effects on toroidal torque in this more accurate model are analyzed based on numerical computations in NEO-RT [4, 5].

References