Gyrokinetic simulation of magnetic islands in tokamaks
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The dynamics of magnetic islands in tokamaks is studied by means of gyrokinetic simulations. In the gyrokinetic flux-tube code GKW [1] a rotating magnetic island structure has been implemented. Both the island width and the rotation frequency are treated as input parameters and thus are kept constant during each simulation. The associated electrostatic potential is calculated self-consistently by means of the Poisson equation, the response of both ions and electrons being determined by gyrokinetic equations. We develop our investigation along two lines. Firstly, the non-turbulent tearing mode dynamics in tokamaks is studied, with the purpose of examining the role of toroidal geometry, finite Larmor radius effects, self-consistent potential, which are included in our numerical model. For rotating magnetic islands, when the small scale turbulence is filtered out, new finite-orbit width phenomena are observed. Around the separatrix (as already suggested in [2]) and around the rational surface, trapped ions tend to respond adiabatically to the electrostatic potential. For small islands this contribution to the perturbed density, which depends on the island rotation frequency, opposes the well-known flattening of the density profiles within the island region when the island is rotating in the electron diamagnetic direction, potentially playing a major role in limiting the effectiveness of the neoclassical drive.

Secondly, the modification of the turbulence due to the presence of a magnetic island structure is considered for a wide range of input parameters. Although the aforementioned flattening of the pressure profile in the island region reduces considerably the drive for ITG modes, the turbulence can be shown to be convected inside the island. A large-scale electrostatic vortex, characterized by a periodic change of sign, has been observed inside the island region [3]. This vortex has a noticeable impact on the transport processes, enhancing among others the flattening degree for trapped particles, and thus the neoclassical drive. Moreover, the abrupt variation of the electrostatic potential occurring at the island separatrix leads to a straining of the turbulent eddies that reduces the transport across the separatrix itself, analogously to zonal flows on unperturbed magnetic surfaces.

References