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# Test particle approach for transport studies in the RFP

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## Abstract

We present the results of a numerical study concerning the magnetic field topology and the particle transport in various regimes of the Reversed Field Pinch (RFP) configuration. The study has been realized by means of the code ORBIT, whose outputs have been compared with experimental measurements taken in the RFX and MST reversed field pinch devices. The Hamiltonian guiding center calculation of particle motion implemented in the code [1] is designed to follow test particles trajectories for long integration times. Single particle motion and particle diffusion in different background particle distributions and magnetic fields may be studied.

The toroidal RFP equilibrium has been described using the $\mu\&p$ model with a $2^{\text{nd}}$ order Shafranov correction. Radial magnetic field eigenfunctions of m=1 and m=0 modes have been obtained by solving the Newcomb equation. In particular we examine the standard Multiple Helicity states (flat $n$ spectrum), the Quasi Single Helicity states (peaked spectrum) [2], and the low magnetic turbulence regimes obtained in Pulsed Poloidal Current Drive experiments [3]. Analysing the Poincare plots corrisponding to these conditions, clear evidence of islands with conserved flux surfaces is found in QSH regimes. Such structures are well correlated with experimental data, in particular with the soft X-ray tomographic reconstructions of the plasma.

The presence of coherent helical magnetic structures, hotter than the background, is a clear indication of the existence of a region of reduced transport in the plasma core. In order to model the observed confinement changes in QSH spectra and to predict what would happen if a pure SH could be reached, a numerical study of particle transport has been performed, taking into account the effect of the interactions with the background plasma particles. The collision operator includes both the pitch angle scattering [4] and the classical scattering.

The diffusion of ensembles of mono-energetic test particles, with random initial pitch distribution, has been studied computing the loss time, defined as the time needed to lose 50% of the particles deposited in the plasma core out from a preset $\psi$ =const surface. Losses resulting from static magnetic perturbations or magnetohydrodynamic fluctuations can be quantified, and a detailed analysis in the SH, QSH and MH conditions has been done, showing in particular the benefit of the conserved flux surfaces inside the magnetic islands with respect to the chaotic (and highly diffusive) MH configurations. Electrons and ions test particles are characterized by different loss times when no electric field is present, so the latter must be introduced to make the quasi-neutrality approximation valid.

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