Orbital Spectrum Analysis of Fast Ion drift motion and transport in toroidal magnetic field configurations

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The dynamics of Energetic Particles (EP) in a fusion reactor is subject to extensive investigation mostly due to their impact concerning the confinement and heating of the plasma bulk. Excessive thermal loads on Plasma Facing Components (PFL) and diagnostics, radial transport of mass and energy compromising the heating efficiency, as well as interaction between EP and MHD modes, may severely degrade the energy balance of the fusion reactor. The Guiding Center (GC) theory [1] has been widely utilized in order to calculate EP trajectories in toroidal magnetic fields. In such configurations, the GC motion is integrable and the Orbital Spectrum (OS) of the drift motion determines the EP transport properties under resonances with non-axisymmetric perturbations.

Explicit analytical formulas for the OS have been reported for the simplified case of Zero Drift Width (ZDW) approximation in Large Aspect Ratio (LAR) equilibrium [2]. Our study focuses on the numerical calculation of the OS taking properly into account the Full Drift Width (FDW) effects in an axisymmetric equilibrium. Our goal is to construct a systematic mapping relating the kinetic characteristics of an EP (energy, momentum and pitch angle) with its bounce and toroidal precession frequencies. The latter are crucial for obtaining the underlying resonance conditions with various non-axisymmetric perturbations [3]. The validity and the accuracy of the model was checked against experimental results acquired from Fast Ion Loss Detector (FILD) arrays installed in AUG [4], in several experimental shots investigating MHD, NBI, and ICRH induced fast ion losses [5, 6]. The calculated orbits and drift frequencies of the expunged ions have been found to be in a very good agreement with the experimentally obtained data.

References:

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