2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Study of transport modulation by magnetic islands in different magnetic configurations

F. Auriemma[1], D. Lopez-Bruna[2], R. Lorenzini[1], B. Momo[1], I. Predebon[1], S. Spagnolo[1], Y. Suzuki[3]
[1] Consorzio RFX, Padova
[2] Laboratorio Nacional de Fusion CIEMAT, Madrid
[3] National Institute for Fusion Science, National Institutes of Natural Sciences, Toki

e-mail: fulvio.auriemma@igi.cnr.it

In magnetically confined experiments the presence of rational surfaces modifies the magnetic configuration with one or more islands embedded in the main plasma. The islands strongly influence particle and heat fluxes, hence their role must be included in the study of the transport properties. For this reason a new approach in modelling transport in presence of islands is presented: this method, dubbed Multiple Domains Scheme (MDS), with some simplifying assumptions, is directly applicable to 1.5D transport codes. In MDS three regions (core, island and outer part) are identified inside the plasma, all interfaced by the separatrix that acts as common boundary through which thermal and particle fluxes can be exchanged. In each domain a monotonic radial coordinate can be chosen and the metric elements can be computed accordingly. The MDS has been implemented in a new numerical tool, called Multiple Axis Solver (MAxS) [1]. To build a straight-field-line coordinate system and to compute the metric elements needed by MAxS, a new method that starts from discretized (Poincaré) magnetic field maps has been also developed [2].
Thanks to its flexibility, MAxS can be exploited to study transport in various plasma configurations: its application to LHD, a heliotron device, and to RFX-mod, a Reversed Field Pinch machine, is here presented.
In LHD, a large m/n=1/1 magnetic island can be induced in the edge region by means of external coils. In stationary condition, the island alters the kinetic quantities appearing, for example, as a flat region in the electron temperature profile. To properly test the cross-field diffusivity in background plasma and inside of the island region, perturbative methods, such as heating modulation or pellet injection, are preferable. In previous works [1,3] a clear reduction of the transport in the island region has been found. Those studies have been performed, for simplicity, starting with a magnetic field given by the vacuum component. Now, the comparison of the transport properties of plasma with islands in LHD using the vacuum field and the more realistic finite beta configuration will be presented.
MAxS has been exploited also in the RFX-mod Reversed Field Pinch device in order to study transport properties of the Quasi Single Helicity (QSH) states. In QSH electron ITBs are routinely observed both in correspondence of the m=1 magnetic island of the dominant mode (Double Axes – DAx – state), and when such island grows enough to evolve in a Single Helical Axis (SHAx) equilibrium. ITBs generate strong temperature gradients on which high frequency small-scale electromagnetic fluctuations arise, as observed in the RFX-mod plasma [4]. The comparison of experimental data with gyrokinetic simulations [5], identifies such fluctuations, with good confidence, as microtearing modes.
There is a growing awareness that microturbulence (with wavelength of the order of a few ion Larmor radii) might be invoked as responsible for a non-negligible level of transport.
The contribution of such instabilities to the energy transport of DAx and SHAx states will be compared, for the first time: the modes amplitude will be evaluated and related to the corresponding temperature gradient and thermal diffusivity, as estimated by the MAxS code. This comparison will include the evaluation of the radial location of the thermal gradient and the distance from the probe location, since these factors can affect the amplitude measurement.

References:
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