Spontaneous mitigation of anomalous transport in RFX-mod helical regimes.

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The understanding of particle and energy transport is a crucial step in the path towards the fusion achievement. In fusion community, particular attention is devoted to the study of transport mitigation phenomena which lead to the onset of Transport Barriers in Tokamaks, Stellarators and RFPs. In RFX-mod electron Internal Transport Barriers (eITB) are the result of a spontaneous plasma self-organization process which leads the plasma to the Single Helical Axis SHAx state [1]. In such regime the spectrum of MHD instabilities is monochromatic; one mode (the dominant one) has large amplitude, whereas the others (the secondary ones) are damped. The nature of transport in SHAx state is still matter of debate. The development of eITBs has been interpreted as a result of a strong reduction of plasma stochasticity accompanied by the recovering of Cantori in the barrier region. Still the residual stochasticity plays a role as suggested by the scaling of the effective thermal conductivity $\chi_{\text{eff}}$ with the amplitude of secondary modes.

Aim of this study is to deepen the comprehension of the mechanism driving transport in presence of eITBs in RFX-mod. We discuss whether transport in the core can still be described within the theory of stochastic transport [2-4] in SHAx as in Multiple Helicity state (MH), where many MHD modes have comparable amplitude. Lights are also shed on the mechanisms acting at the plasma edge. The analyses, carried out with the ASTRA code, exploit the recently available measurement of the ion temperature, whose gradient is a key ingredient in the model of transport in a stochastic magnetic field, being the ambipolar velocity $V_{\text{amb}} \sim D \nabla T_i/T_i$ [5].

The results show that the decreased core stochasticity leads the plasma in a reduced transport regime: in SHAx the diffusivity along the 90% of the radius is $D \sim 1 \text{m}^2\text{s}^{-1}$ whereas in the MH state $D \sim 30 \text{m}^2\text{s}^{-1}$. Nevertheless transport in SHAx is still anomalous, as highlighted by the comparison with the neoclassical $D (~ 0.1-1 \text{m}^2\text{s}^{-1}$ [6]) computed by ORBIT.

The same picture well describes both the particle and the energy transport in the plasma core: the comparison with the $\chi_{\text{eff}}$ indicates that the ratio $\chi_{\text{eff}}/D$ is about $\left(\frac{m_i}{m_e}\right)^{0.5}$ (energy lost via electron channel, particles lost via ion channel), consistently with a stochastic transport theory. As for the tokamak, the plasma core and edge seem to be affected by different transport mechanisms. Indeed in the plasma external region (last 10% of the radius) the stochastic transport is suppressed, no $V_{\text{amb}}$ is needed and the edge diffusivity is likely to be ruled by convective flows and turbulent blobs.