Influence of stiff temperature profile on island stabilization by RF heating

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Theory and experiments show that turbulent transport in tokamaks is triggered above a critical temperature gradient, and leads to resilient (also refered to as stiff) profiles above this threshold [1]. Inside magnetic islands, where the temperature profile is flattened, a reduced diffusivity is expected and indeed measured [2]. The consequences of profile stiffness on island stabilization by RF heating has recently been investigated analytically and numerically [3], using a characteristic form for heat diffusivity as $\chi_\perp = \chi_\perp^{ref} \left|T'/T'_{eq}\right|^{\sigma-1}$, with σ the stiffness parameter and T_{eq} the equilibrium temperature. This formulation reproduces the low diffusivity below a threshold in temperature gradient, and the large diffusivity above this threshold, with an actual equilibrium temperature gradient that lies in the turbulent transport dominated regime. We find that the stabilization efficiency varies as $(P_{RF}/P_{eq})^{1/\sigma}$, with P_{eq} the power injected inside the island position and P_{RF} the additional heat source centered at the O-point of the island. For non-stiff profiles ($\sigma = 1$), we find a good agreement with known results [4]. In the most common case where the ratio (P_{RF}/P_{eq}) is small, the stabilization can be much larger than anticipated when assuming non-stiff profiles. Numerical simulations with the XTOR code [5], where a RF heat source is deposited at the O-point of a (2,1) island, shows a good agreement with the analytical model. The stabilization of Neoclassical Tearing Modes by the combined effect of heat and current drive can then be addressed in more realistic conditions [6].

References

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