# Quasisymmetry far from the magnetic axis

Iván Calvo[1], Félix I. Parra[2,3], José Luis Velasco[1] and J. Arturo Alonso[1]

[1] *Laboratorio Nacional de Fusión, CIEMAT, Madrid, Spain*
[2]*Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, UK*
[3]*Culham Centre for Fusion Energy, Abingdon, UK*

In tokamaks, rotation has been shown to quench turbulence and stabilize magnetohydrodynamic instabilities. It is reasonable to ask whether neoclassical flow damping in stellarators can be sufficiently weak to allow large plasma rotation. Recently, it has been proven [1] that flows are undamped if and only if the stellarator is quasisymmetric, and that quasisymmetry is equivalent to the vanishing of the flux surface averaged radial electric current for arbitrary plasma profiles. But perfect quasisymmetry throughout the whole plasma cannot be achieved [2].

Therefore, it only makes sense to think of quasisymmetry as approximate, and for that reason we need to study stellarators close to quasisymmetry. We do this rigorously by computing the scaling of the flux surface averaged radial electric current with the size of the deviation from quasisymmetry. We show that the effect of a deviation is very different depending on its helicity. For low helicity deviations, the current scales like the square of the deviation [3]. Large helicity deviations are more deleterious and, for low collisionality, the current scales linearly with the amplitude of the deviations [4, 5]. These results allow us to determine the maximum size of the deviations from quasisymmetry that are acceptable for the stellarator to admit large flows; i.e. for the stellarator to behave as quasisymmetric in practice.

Then, we address the question of how close to quasisymmetry can a stellarator actually be. More precisely, given a perfectly quasisymmetric flux surface, we would like to know how much one can separate from it before exact quasisymmetry fails. Garren and Boozer [2] answered the question in detail in a neighborhood of the magnetic axis. We will present the results for a generic flux surface. Since, at this point, we know the maximum size of the deviation from quasisymmetry that is admissible, and also the size of the region around a flux surface in which exact quasisymmetry can be imposed, we can estimate the maximum size of the region of the stellarator in which it behaves as quasisymmetric in practice. This should be useful to provide criteria for the design of future quasisymmetric stellarators.

**References**

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