Geometry of the m=1 magnetic island in a tokamak

S.V.Annibaldi, P.Buratti, E.Giovannozzi and F.Zonca

Associazione EURATOM/ENEA sulla Fusione, Centro Ricerche Frascati, CP 65, 00044 Frascati, Roma, Italia

Magnetic islands with dominant poloidal mode number $m = 1$ develop in tokamaks in the presence of a value $q = 1$ of the safety factor, either accompanying sawtooth activity, or in the form of persistent ("snake") oscillations. The knowledge of the related topology can help us understanding their formation and their stability. Observations [1] from the Frascati Tokamak Upgrade (FTU) bring evidence that the geometry of such structures derives from the superposition of several harmonics with single helicity, so a nonlinear model must be used. Moreover, in several FTU discharges, $m = 1$ rotating islands can live six times longer than the energy confinement time, leading us to consider them as helical equilibrium structures.

We take a helical modification of the Grad-Shafranov equation in cylindrical approximation, and, in radial regions away from $r = r_s$, where r_s is the radius of the $q = 1$ magnetic surface, we expand the helical magnetic flux in an axisymmetric part and a small first harmonic perturbation, and thus obtain a linearized equation. Around $r = r_s$, the axisymmetric helical flux has an extremum, so it is impractical to use flux coordinates there, therefore, in a region of width $2\Delta r$ around r_s, we write a nonlinear equation for the full helical flux. We finally connect the three solutions by continuity requirements and obtain the resultant helical flux giving us the topology of the island, that is in accordance with experimental results.

Our study has underlined several features of the island: in first instance, in order not to have discontinuities in joining the three radial regions, Δr has to be finite, $\Delta r > 0.35 r_s$, proving that the structure has a consistent nonlinear component that cannot be neglected. Also, the satisfactory results found in cylindrical geometry show that toroidal effects can be considered as corrections. The calculated current density does not display sensible changes from the axisymmetric one, and there is no spike in correspondence with the x-point, so there are no current sheets linked to those islands.

References

[1] E. Giovannozzi et.al., *Nucl. Fusion*, **44** (2004) 226.