Traces of stable and unstable manifolds in heat flux patterns

A. Wingen[1], M. Jakubowski[2], K.H. Spatschek[1,2], and S.S. Abdullaev[2]
[1] *Institut für Theoretische Physik, Heinrich-Heine-Universität Düsseldorf, D–40225 Düsseldorf, Germany*
[2] *Institut für Plasmaphysik, Forschungszentrum Jülich GmbH,*
EURATOM Association, Trilateral Euregio Cluster, D–52425 Jülich, Germany

Abstract

Experimental observations of heat fluxes on divertor plates of tokamaks show typical structures (boomerang wings) for varying edge safety factors. The heat flux patterns follow from general principles of nonlinear dynamics. In principle, the structures are related to the topology of large connection lengths of magnetic field lines. The selection of those patterns of large connection lengths which ultimately determine the heat flux pattern is due to the unstable and stable manifolds of the hyperbolic fixed points of the last intact island chain. The manifolds attract co- (with respect to the magnetic field direction) and counter-moving particles, respectively.

Necessary for significant heat loads are sufficiently large connection lengths to shortcut the (inner) hot plasma with the wall. Large connection lengths of the magnetic field lines are not sufficient. Particle motion should also converge towards the magnetic field lines which rapidly penetrate from the inside to the outside. Those magnetic field lines which satisfy the attractive requirement are close to the unstable (for co-moving particles) and stable (for counter-moving particles) manifolds of the hyperbolic fixed points of the last intact island chain. Direction of particle motion should be towards the wall.

Based on the manifold analysis, the experimental observations can be explained in full detail. Quantitative results are presented in terms of the penetration depths of field lines.