Order and chaos in some Hamiltonian systems of interest in plasma physics

B.Weyssow[1], D. Constantinescu[2]

[1]. Université Libre de Bruxelles, Association Euratom-Etat Belge, Belgium
[2]. Université de Craiova, Association Euratom-Mec, Romania.

Hamiltonian systems are useful tools for modeling important phenomena, like anomalous sub-diffusion or super-diffusion, in hot magnetically confined plasmas in particular when they exhibit simultaneously chaotic and regular dynamics. The phase space is then likewise a complex mixture of stochastic zones and regular zones. We study the behavior of trajectories in a family of non-twist Hamiltonian maps describing the dynamics of TOKAMAK magnetic field lines in different magnetic reconnection regimes. Of the few functions defining the maps, the winding function (or in tokamak terminology: the inverse of the safety factor profile) is crucial for it determines the layering of the poloidal cross section of the torus in terms of radial positions of magnetic island chains, KAM tori, cantori aso. In "normal" conditions this function is monotoneously decreasing from the magnetic axis to the edge.

When the winding function is quadratic, with a maximum, as for modeling the reversed shear tokamak, a regular zone appears in the neighborhood of the maximum. We analytically locate and describe this regular zone (the so-called internal transport barrier) that separates the core stochastic region (surrounding the magnetic axis) and the globally stochastic zone (in the peripheral zone of the TOKAMAK). Also, various magnetic field line reconnection scenarios, that are allowed only in the regular zone, are analyzed within of the framework of chaotic behavior. Similar aspects in non-twist systems but with monotone winding function (modeling positive (or negative) shear TOKAMAKs) are also studied. Practical consequences derived from the analytical results are put forward.