STUDYING THE STABILITY OF MAGNETIC ISLANDS IN A NONLINEAR DYNAMICAL SYSTEM: ERGODIC MAGNETIC LIMITER IN TOKAMAK

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We used EML (Ergodic Magnetic Limiter) in order to optimize the movement of plasma in Tokamak. It is as a nonlinear dynamical system. In this paper two main sections are studied as follows:

1- Chaotic magnetic field lines in Tokamak:

The limiter that be used in this research is a wire like antenna and the electrical current "I" passes through it**.** We have only one wire as limiter in throughout of Tokamak. The wire generates around itself two magnetic fields: Toroidal and Poloidal fields. The fields cause plasma particles are forced thus the plasma will not be contacted the wall of Tokamak. By solving Laplace's equation and considering the perturbed magnetic field, we can obtain flux surfaces equation with using boundary conditions. The field lines equations can not be exactly integrated in the region of limiter. Assuming the perturbation parameter (p) is small; we can consider that equations are integrated. So we can obtain EML map for magnetic field lines. The map is symplectic and includes two regions: a) with limiter b) without limiter.

We formed Jacobian Matrix for the map and studied the stability of system. We obtained the fixed points of period one and two for the map in order to compare with bifurcation diagram. Then we drew poincare' surface of section for different perturbation parameter values (p) and different magnetic shear values (s) and acquired the relation width of islands and "p" & "s" parameters. With due attention to relation chaotic region and "p" & "s" parameters; we realized that "p" should be decrease and "s" should be increase in order to control the chaos and limit it near the wall of Tokamak.

Afterwards, with use of stochasticity parameter, we obtained critical perturbation parameter in order to transport the local chaos to global chaos.

2- Destruction of islands of stable

We will see that there are two main mechanisms for the destruction of the islands of stable:

a) The stable periodic orbit at the center of the island becomes unstable, by an equal period or a period doubling bifurcation. Then a chaotic domain is produced around it, which increases outwards. Finally, the large chaotic sea outside the island and the inner chaotic domain at the center merge and the island is destroyed.
b) The island is limited on the outside by two equal or double period unstable periodic orbits that come closer and closer to the center of the island. These unstable periodic orbits are followed by chaotic domains. When they merge, the stable periodic orbit at the center of the island becomes unstable, and the outer chaotic domains join into a large chaotic sea.

With use of KAM theory, we could obtain rotation number of magnetic islands which observed in poincare' surface of section. For different "p" and "s" parameters, we considered stability of islands and realized that with escaping secondary islands from last KAM curve, these islands become unstable and are going to be destroyed gradually. By using continued fraction of KAM theory "epicyclic frequency" was obtained for secondary islands.

Consequently via creation chaotic region near the wall, we can prevent that plasma contacts with the wall of Tokamak. With this method we can control the movement of plasma.

Keywords: Control of Chaos, Control of plasma, Nonlinear Control, Nonlinear Dynamics