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CHAOTIC DYNAMICS IN FUSION PLASMAS

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1. INTRODUCTION

In the present work, we describe a model for the study of particles transport at the plasma edge. The plasma is confined in a Tokamak, and the transport is affected by drift waves, which are mostly responsible for the escaping of particles, an important problem for understanding of fusion plasmas. The Hamiltonian formalism provides the basic equations of motion, which are dependent on the form of a electric potential function. This function is characterized by an equilibrium potential perturbed by drift waves. Defined the equilibrium potential, a map is constructed from the equations of motion. Finally, numerical results are presented for some sets of parameters.

2. THE MODEL

In order to study the transport properties at the plasma edge, we consider a similar model to the one described in Ref. [1]. The guide center of the particle trajectory is governed by the following equations:

$$\frac{dy}{dt} = -\frac{E_x}{B} \qquad \frac{dx}{dt} = \frac{E_y}{B} \tag{1}$$

These equations may be rewritten in the canonical form:

$$\frac{dy}{dt} = \frac{\partial h(y,x,t)}{\partial x} \qquad \frac{dx}{dt} = -\frac{\partial h(y,x,t)}{\partial y} \tag{2}$$

The hamiltonian is given by:

$$h(y,x,t) = \frac{\varphi(x,y,t)}{B}, \tag{3}$$

where generalized coordinate is y and the conjugate momentum is x. Now we assume that the electric potential function may be constructed in the following way:

$$\varphi(x,y,t) = U(x) + \sum_{j=-\infty}^{+\infty} A\cos(k_y y - j\omega_0 t), \tag{4}$$

where the equilibrium potential is:

$$U(x) = C(x-a)^{2n+1} \tag{5}$$

with $n = 1, 2, 3....$ Applying the set of transformations:

$$a = \frac{2\pi A k_y}{\omega_0 B} \qquad b = \frac{2\pi k_y}{\omega_0 B} C(2n+1) \tag{6}$$

$$x' = x - a \qquad y' = \frac{k_y y}{2\pi}, \tag{7}$$

and using the same integration method presented in Ref. [2], the equations of motion are reduced to the following map:

$$x'_{i+1} = x'_i + a\sin(2\pi y'_i) \tag{8}$$

$$y'_{i+1} = y'_i + b x'^{2n}_{i+1} \tag{9}$$

This is a nontwist map, i.e., a map with a rotational transform profile with a shearless point.

3. NUMERICAL RESULTS

Figures 1 and 2 show the results from some numerical experiments using the previously obtained map. In these figures, we observe the formation of islands, chaotic regions and barriers.The barriers are KAM surfaces and meanders at the shearless region.

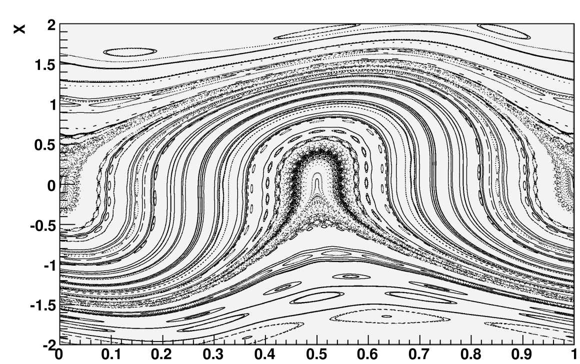

Figure 1 – Parameters: n = 1; a = 0.35; b = 0.1.

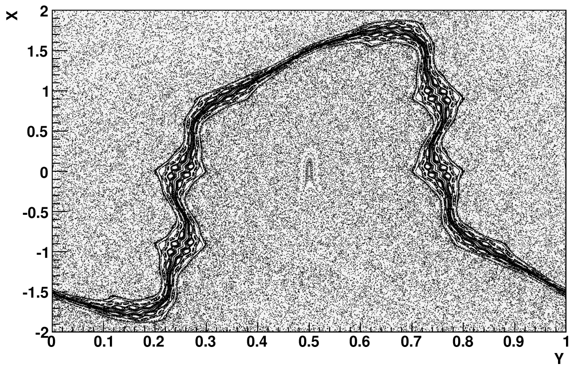

Figure 2 – Parameters: n = 1; a = 0.95; b = 0.1.

References

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