Fermi acceleration in a system of coupled billiards

Rodrigo Simile Baroni[1*], Ricardo Egydio de Carvalho[1]

[1]Universidade Estadual Paulista – IGCE – Unesp Rio Claro

***e-mail: r.baroni@unesp.br**

1st Perspectives on Oscillation Control

Introduction

Fermi acceleration (FA) is a mechanism of undetermined energy growth that has been extensively studied in the past few years, mainly in billiard systems [1]. The main result on this subject is known as the LRA conjecture, which states that the existence of chaotic dynamics in the static version of a billiard is a sufficient condition to observe the FA when the boundaries are periodically perturbed [2]. We consider two annular billiards (AB) which individually do not present FA and couple them, so particles visit both sides of the resulting system. In this configuration, there are no longer constants of motion and FA is observed.

Results and Discussions

Two configurations of the annular billiard are considered: **i)** concentric and static, in this case the particle's energy and angular momentum are preserved and therefore the system is integrable; **ii)** concentric and with pulsating inner boundary, so that the particles velocities can change within a chaotic sea limited by invariant tori. Both geometries and phase planes are shown in Figure 1.

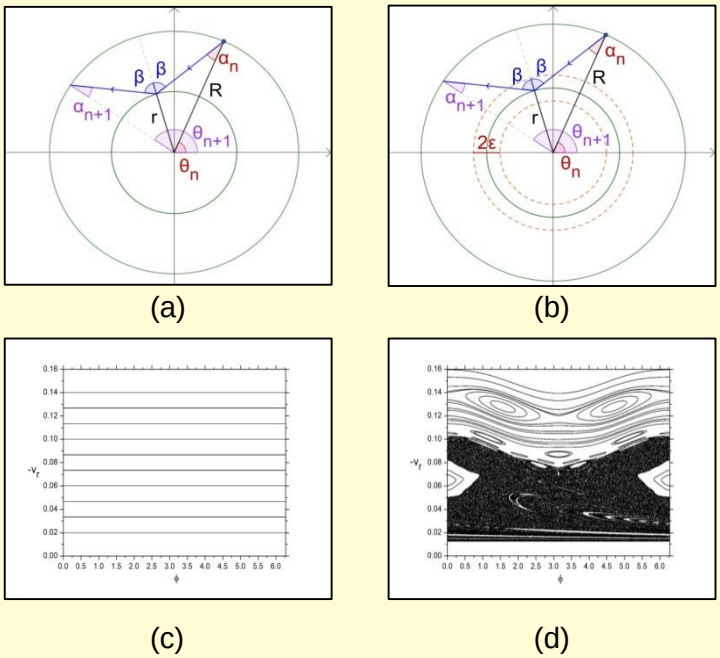

Figure 1 – (a), (c) Static AB and corresponding energy phase plane , (b), (d) AB with pulsating inner boundary and amplitude 2ε and energy phase plane.

We join the two billiards and open a hole in the boundary they are in contact with. The width of the hole is controlled through the parameter named b**.** The hole allows particles to visit both billiards and experience the two different types of dynamics. The billiard plane is shown in Figure 2 with a few trajectories.

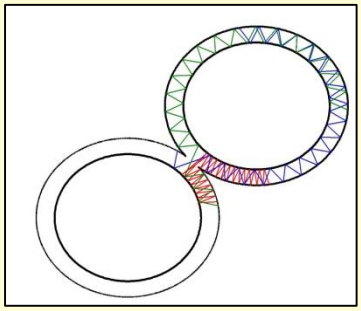

Figure 2 – Coupled billiards and three trajectoreis.

Figure 3 (a) shows the particles mean velocity for different values of hole width b. We see that b controls the time scale at which FA is observed. In Figure 3 (b) we fix the hole width and evaluate the mean velocity of ensembles of different initial velocities. We observe that the smaller the initial velocity, the earlier the FA is observed .

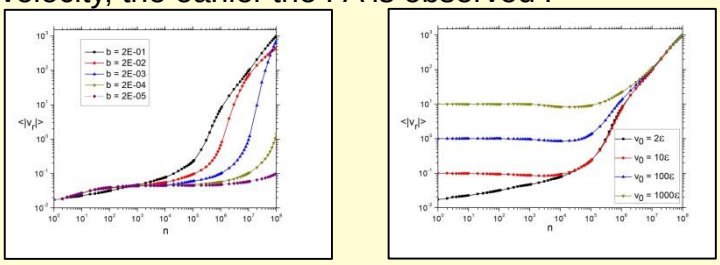

Figure 3 – Mean velocity for (a) fixed initial velocity and varying b and (b) fixed b and varying initial velocity.

Conclusions/Remarks

When a particle exchanges billiards, its angular momentum changes. This, along with the pulsating boundary, breaks all the constants of motion allowing FA to happen.

References

[1] R. E. de Carvalho, F. C. Souza, E. D. Leonel. **Phys. Rev. E**, 73. 2006.

[2] A. Luskutov, A. B. Ryabov, L. G. Akinshin. **J. Phys. A**, 33. 2000.

Acknowledgment:

FAPESP FUNDAÇÃO DE AMPARO À PESQUISA DO ESTADO DE SÃO PAULO

CAPES

CNPq