

Reducing or enhancing chaos using periodic orbits

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Abstract

A method to reduce or enhance chaos in Hamiltonian flows with two degrees of freedom is discussed. This method is based on finding a suitable perturbation of the system such that the stability of a set of periodic orbits changes (local bifurcations). Depending on the values of the residues, reflecting their linear stability properties, a set of invariant tori is destroyed or created in the neighborhood of the chosen periodic orbits.

An application is done on the interaction between a wave and a bunch of charged particles. This type of interaction is encountered in many branches of applied physics ranging from particle accelerators to laser physics (Free Electron Laser). Generically, this self-consistent interaction leads to an exponential increase of the intensity of the wave due to the formation of clusters of charged particles. However, after a transient time, these clusters lead to undesirable oscillations of the intensity of the wave. There is therefore a crucial need to control the dynamics of these systems in order to improve the performance of the devices.

The wave-particle interaction can be cast in a Hamiltonian form with $N+M$ degrees of freedom, where N degrees of freedom are associated with the N charged particles interacting with M electromagnetic waves. The aim of this presentation is to show that it is possible to influence by external perturbation the dynamics of the particles in order to enhance the stability of the system resulting in a reduction of the oscillations of the waves. We show that an appropriate tuning of the parameters is able to reduce by an order of magnitude the amplitude of the oscillations without reducing the total power of the wave.

References

- [1] R. Bachelard, C. Chandre, X. Leoncini. Reducing or enhancing chaos using periodic orbits. submitted, 2006