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Topic: Chaos Control

Reducing or enhancing chaos using periodic orbits

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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 Greene's residues, reflecting their linear stability properties, a set of invariant tori is destroyed or created in the neighborhood of the chosen periodic orbits.

Two applications are performed. The first one is on the self-consistent interaction between a wave and charged particles The wave-particle interaction is encountered in many branches of applied physics, e.g., plasma physics, particle accelerators or 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.

The second application is on chaotic mixing in a two-dimensional incompressible flow. More precisely, the advection of passive tracers in an oscillating vortex chain is investigated. It is shown that by adding a suitable perturbation to the ideal flow, the induced chaotic advection exhibits two remarkable properties which do not hold in the case of a generic perturbation: Particles remain trapped within a specific domain bounded by two oscillating barriers (suppression of chaotic transport along the channel), and the stochastic sea seems to cover this whole bounded domain (enhancement of mixing within the rolls).

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[1] R. Bachelard, C. Chandre, X. Leoncini, *Reducing or enhancing chaos using periodic orbits*, Chaos **16**, issue 2 (2006)

[2] T. Benzekri, C. Chandre, X. Leoncini, R. Lima, M. Vittot, *Chaotic advection and targeted mixing*, Phys. Rev. Lett. **96**, 124503 (2006)