Diffusions in fluctuating geometries

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Lateral diffusions on interfaces are of great biological importance and can be modeled by stochastic motions on 2D surfaces. Though real interfaces present highly fluctuating geometries, usual models of lateral diffusions neglect these fluctuations altogether. It is shown here that geometry fluctuations couple non linearly to diffusions and, contrary to common belief, have a drastic influence on diffusions on all scales, including scales much larger than those on which the geometry fluctuates . Analytical and numerical results also indicate that, generically, the net large-scale effect of fluctuations cannot be taken into account by simply renormalizing the diffusion coefficient and that realistic mean field models are necessarily more complicated.

Patterns formation in optical parametric oscillator

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We study the light flows that come out from a optical parametric oscillator (a Fabry-Perot resonator with a nonlinear cristal inside that couples the cavity modes). These flows are associated with the dynamics of two noncommuting quadratures of each mode component of the light field. We show that manipulating two parameters, the pump intensity and cavity detuning, we can access a rich variety of phases of the light, among them a Lifshitz modulated phase and a Kosterlitz-Thouless type of phase transition, as found in superfluid and others bidimensional systems.

Many-body effects in the coalition formation process

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Two-body interactions in the process of coalition or block formation do not describe all features occurring in real world. Therefore, an study of the effects of three-body interactions in coalition formation is presented. The model can be used to study conflicts, political struggles, political parties, social networks, wars and organizational structures. As an application, we analyze a simplified model of the recent invasion of Iraq.

Synchronized release in sensory synapses

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Most of the information in our brains is conveyed by discrete events (action potentials) that can be interpreted as a digital code. However, our senses receive analog inputs from the environment. At some early stage of sensory processing a sort of conversion must be performed. Primary receptor cells generate graded potentials in response to stimuli. But their primary nerve afferents re-encode this information as a temporal pattern of action potentials. In auditory, visual and vestibular systems a highly specialized synapse (ribbon synapse) plays a chief role in such a conversion. The ribbon synapse has unique features: it can release neurotransmitter at high rates for sustained periods, it is extremely fast and reliable and it has little or no plastic behavior. It is thought to achieve this by means of coordinated multi-vesicular fusion; but the way it does remain unknown. In this work we propose a dynamical model of the ribbon synapse that is able to reproduce the main features of these units. Unlike previously reported models, the dynamics of the vesicles of neurotransmitter is strongly coupled. We use our model to compare two recently proposed underlying mechanisms of multi-vesicular release: compound fusion and coordinated release. For the case of the auditory system, we also show that these synapses are crucial to encode temporal information in the sub-millisecond range, a requirement for the localization of sound sources and the perception of pitch.

Fermi acceleration and dissipation on the annular billiard

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We study the phenomenon of unlimited energy growth for a particle moving in the annular billiard. The model is considered under two different scenarios: static and with breathing boundaries. We show that when the dynamics is chaotic for the static case, the introduction of a time-dependent perturbation allows that the particle experiences the phenomenon of Fermi acceleration even when the oscillations are periodic. On the other hand, some properties of the annular billiard under the presence of weak dissipation are also studied. We show that, when the colisions with the boundaries are inelastic, the average energy of a particle acquires higher values than its average energy of the conservative case. The creation of attractors, associated with a chaotic dynamics in the conservative regime constitute a generic mechanism to increase the average energy of a particle in a dissipative dynamical systems.

Nonlinear wave-vortex interaction

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We present an experimental study on the effect of a electromagneticaly generated vortex flow on parametrically amplified waves at the surface of a fluid. The underlying vortex flow, generated by a periodic Lorentz force, creates spatio-temporal fluctuations that interact nonlinearly with the standing surface waves. We characterize the bifurcation diagram and measure the power spectrum density (PSD) of the local surface wave amplitude. We show that the parametric instability threshold increases with increasing intensity of the vortex flow, as do the saturation exponents of the fluctuating wave amplitude. A theoretical model is proposed to describe the observed behavior as a quasi-reversible system in presence of noise.

Encoding and transmission of information in the brain: differences between fMRI and neurophysiological data

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We analyze using information theory the encoding and transmission of information in the brain from fMRI and neurophysiological recordings. The growth of the transmitted information is analyzed as recordings, from different voxels in one case and cells in the other, are grouped together. In the first case a subjective rating produced by warm and cold stimuli applied to humans is analyzed from functional magnetic resonance neuroimaging data on individual trials from the activations of groups of voxels in the orbitofrontal and medial prefrontal cortex pregenual cingulate cortex. The information