Miércoles, 18 de febrero

Propiedades electrónicas del grafeno

Prof. José González

Instituto de Estructura de la Materia (CSIC)

Abstract

Pasaremos revista a las propiedades electrónicas no convencionales que surgen en grafeno del comportamiento de las cuasipartículas como fermiones de Dirac sin masa. Discutiremos la dependencia lineal de la conductividad con el dopado, la cuantización anómala de la conductividad Hall y los efectos del desorden en la hoja de grafeno. Prestaremos atención también a las propiedades del sistema estadístico de muchos cuerpos, con el propósito de identificar los efectos más importantes de la interacción electrónica.

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Miércoles, 25 de febrero

La entropía de los agujeros negros en gravedad cuántica de lazos

Prof. Fernando Barbero

Instituto de Estructura de la Materia (CSIC)

Abstract

El seminario se concentrará en describir el cálculo de la entropía de los agujeros negros en gravedad cuántica de lazos mediante técnicas basadas en teoría de números y combinatoria. Mostraré, en particular, cómo es posible obtener expresiones exactas, en función del área, mediante transformadas de Laplace. Para ello mostraré diversos métodos basados tanto en la resolución de ecuaciones de recurrencia como en el uso de funciones generatrices. Terminaré mostrando que la estructura analítica del integrando de la transformada de Laplace inversa que da la entropía presenta características peculiares que permiten esperar que su comportamiento asintótico explique los resultados obtenidos recientemente sobre la cuantización efectiva de la entropía para agujeros negros microscópicos.

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Miércoles, 4 de marzo

Los modos de Klebanoff en la capa límite de Blasius

Prof. José M. Vega

E.T.S.I. Aeronáuticos (UPM)

Abstract

La capa límite de Blasius es la que aparece en una placa plana paralela a una corriente uniforme de fluido incompresible. Es la configuración de capa límite más sencilla posible y tiene los ingredientes esenciales para estudiar fenómenos de gran interés industrial, como la transición a turbulencia en flujos alrededor de alas de aeronaves comerciales, que produce un aumento brutal de la resistencia de fricción. Los modos de Klebanoff (K) son, en cierto modo, los naturales de la capa límite porque oscilan rápidamente en la dirección transversal a la corriente, pero lentamente en la dirección de la corriente, como sucede con la solución estacionaria. Por tanto, a diferencia de los modos de Tollmien-Schlichting (TS), que oscilan rápidamente en la dirección de la corriente, pueden calcularse mediante ecuaciones linealizadas independientes del número de Reynolds. Aunque son los modos TS los responsables directos de la transición a turbulencia, los modos K no deben ignorarse porque pueden o bien promover el crecimiento de los modos TS (transición bypass) o inhibirlo, dependiendo de la amplitud. El interés matemático de los modos K proviene de que (a) conllevan crecimiento transitorio (transient growth), lo que hace sutil su propia definición como modos; y (b) su descripción numérica es complicada en las cercanías del borde de ataque, donde su comportamiento es singular. Sin embargo, un análisis cuidadoso de la estructura matemática de los modos K pone de manifiesto que pueden describirse y calcularse de modo relativamente sencillo y que tienen estructura modal, en contra de la creencia generalizada a día de hoy. Así se evitan descripciones de estos modos mediante problemas de optimización relativamente artificiales y se da un paso hacia desentrañar el mecanismo de interacción de modos que parece estar en el origen de la transición a turbulencia en capas límite.

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Viernes, 13 de marzo

Optical injection and dynamics of charge and spin current in quantum wells

Prof. Eugene Sherman

Departamento de Química Física (UPV)

Abstract

Optical manipulation of currents and spins is of a great interest for modern spintronics. We begin with the presentation of optical techniques based on the interference of one- and two-photon processes for the current injection in bulk semiconductors and semiconductor structures. Then, we analyze transverse and lateral evolution of optically injected currents in multiple quantum well structures using a hydrodynamic model. The dynamics is very complex even on time scales of the order of one picosecond due to the interplay of Coulomb forces, electron-hole drag effects, and nonlinearity of the equations of motion. The spin currents arising due to the spin-orbit coupling and skew scattering of electrons by holes will be discussed.

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Lunes, 16 de marzo

Equations for step bunch formation in the morphological evolution of nano-scale crystal surface structures below the roughening transition

Prof. Rodolfo Rubén Rosales

Department of Mathematics (MIT)

Abstract

We derive ``Lagrangian'' coordinates continuum equations for the surface evolution, obtained as a limit from a nano-scale description of the dynamics (``discrete'' step-interaction equations). At the nano-scale, below roughening, the crystal surface consists of arbitrarily shaped, interacting steps that move by diffusion of point defects (adatoms) on terraces; and attachment and detachment of adatoms at steps. The cases of diffusion-limited (DL) kinetics, attachment-detachment limited (ADL) kinetics, and mixed DL+ADL kinetics are considered, with the restriction of axial symmetry in the surface.

The standard (``Eulerian'') continuum description fails when step bunching (where a relatively large number of steps coalesce to form ``bunches'' of very closely packed steps) occurs. A numerical investigation of the continuum Lagrangian equations for the ADL case shows that they capture step bunching - where the bunches appear as the product of the interaction between a (destabilizing) negative diffusion (arising from step-line tension effects) and a stabilizing fourth order nonlinear diffusion (arising from the step-step interactions). The local dynamics within each bunch can be described by a (relatively) simple equation - resembling, in some sense, the Kuramoto-Sivashinski equation - combining these two effects.

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Miércoles, 15 de abril

Spin dynamics in Quantum Dots under dc and ac magnetic fields

Prof. Gloria Platero

Instituto de Ciencia de Materiales de Madrid (CSIC)

Abstract

In the last years a large number of experiments has been devoted to the analysis of the electronic current through double quantum dots (DQD's) in the spin blockade (SB) regime. Hyperfine interaction in DQD's releases spin blockade allowing the flux of current and inducing nuclei spin polarization. This interaction gives rise to a feedback mechanism between the spins of the electrons and nuclei, which dynamically modifies the electronic charge occupation and the energy of the electronic levels. In this talk, we propose a model which accounts for hyperfine interaction, as the main spin-flip source, and which allows to obtain the nuclei spin dynamical polarization and its interplay with the electron spin dynamics. We will show how this interplay brings the current to perform self-sustained current oscillations, as experimentally observed. We have considered molecular states as the basis and, from non linear rate equations for the electronic charge occupations and nuclei spin polarization, we obtain the non linear electronic current and dynamical nuclear polarization. As we will discuss, there are different spin flip processes which induce nuclear spin polarization with opposite polarization. We have analyzed their interplay and we have calculated the tunneling current as a function of time, effective exchange interaction (interdot tunneling) and magnetic field.

The second part of this talk will be devoted to analyze spin dynamics in double and triple dots under crossed dc and ac magnetic fields. Recent transport experiments in DQD's under crossed dc and ac magnetic fields show coherent spin rotations of one single electron spin. We will discuss the electron spin dynamics in this configuration and we will extend this analysis to triple quantum dots (TQD's). TQDs in linear o triangular configuration have been investigated, both experimentally and theoretically. TQDs have been proposed as solid-state-entanglers or charging rectifiers.They also motivate fundamental research, because their electronic properties present a rich variety of physical phenomena as spin blockade or electron spin resonance (ESR). Also, TQD's in triangular configuration present Aharonov-Bohm (AB) oscillations. We have analyzed the interplay between AB-phase and coherent spin rotations induced by crossed DC and AC fields in TQD in triangular configuration, filled with up to three extra electrons. We investigate different configurations, i.e. equal or different Zeeman splittings within the three dots. We discuss how coherent population trapping, which occurs in TQD's filled with one electron, is affected by the AC field. The presence of a second extra electron leads to new interesting features in the spin dynamics due to the interplay between spin blockade, AB-interference and coherent spin rotations induced by the AC magnetic field. Current through the system can be blocked either by coherent population trapping or by spin blockade. We will discuss how ESR modifies the spin dynamics in both cases

and how it depends on the magnetic flux through the sample induced by the dc field. Finally, we predict that, for certain sample configurations, bichromatic magnetic fields are able to induce electron coherent trapping in the TQD. Our results indicate that not only electron spin coherence but also electron spin rectification properties in transport can be tuned with AC and DC magnetic fields.

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Lunes, 20 de abril

Rate-dependent Avalanche Size in Athermally Sheared Amorphous Solids

Prof. Anael Lemaitre

Institut Navier (France)

Abstract

Considerable efforts have been spent in recent years to derive constitutive laws for plasticity in amorphous media from a realistic description of the elementary mechanisms of dissipation. It is now agreed that in these disordered systems, plasticity involves "shear transformations", i.e. irreversible rearrangements (or flips) of small clusters of (a few tens of) particles. By analogy with Eshelby transformations, each flip can alter the strain field in its surroundings, hence generate long-range elastic fields. Flips can thus trigger further flips, a mechanism likely to give rise to avalanches. Yet, theories still diverge on the importance to grant to flip-flip correlations. Avalanches were first seen in numerical simulation of athermal systems, but only in the quasi-static limit (at vanishing strain rate), and the question remained outstanding whether they are relevant to experimentally accessible regimes of plastic deformation. After a quick review of quasi-static results, we will see how finite size studies of transverse diffusion under shear at finite strain rate provide evidence that indeed avalanche behavior should always be prevalent under experimental conditions.

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Miércoles, 29 de abril

Transmisión extraordinaria de ondas a través de láminas perforadas

Prof. Luis Martín

Departamento de Física de la Materia Condensada (U. Zaragoza)

Abstract

En 1998 Ebbesen y colaboradores encontraron que la transmisión de luz a través de redes periódicas de agujeros diminutos (menores que la longitud de onda de la luz incidente), perforados en un metal, podía ser órdenes de magnitud mayores que si los agujeros estuvieran aislados. Este descubrimiento ha sido fuente de numerosas investigaciones (efecto del tipo de metal, de la red, la posibilidad de fenómenos similares en agujeros aislados, etc.). En este seminario se resumirán dichos estudios y se presentarán los mecanismos básicos que dan lugar a la transmisión extraordinaria. El conocimiento de estos mecanismos permite la transferencia de este efecto a otros regímenes del espectro electromagnético e incluso a otros tipos de ondas.

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Martes, 5 de mayo

Análisis de la no convexidad y aproximación numérica de las ecuaciones de la magnetohidrodinámica compresible

Prof. Susana Serna

University of California Los Angeles y Universidad Autónoma de Barcelona

Abstract

Las ecuaciones de la magnetohidrodinámica (MHD) compresible forman un sistema no estrictamente hiperbólico de leyes de conservación. La complejidad de la dinámica de ondas de la MHD compresible en comparación con la de las ecuaciones de la hidrodinámica de Euler radica en la presencia del campo magnético que genera nuevas ondas magnéticas y magnetoacústicas. La rotación del campo magnético induce el carácter no estrictamente hiperbólico del sistema de ecuaciones de la MHD y la no linealidad no genuina (no convexidad) de algunos campos característicos locales. En este trabajo presentamos un estudio analítico de la estructura de ondas del sistema de ecuaciones de la MHD compresible basado en la descomposición local en campos característicos. Proponemos una descomposición espectral apropiada de los flujos que permite establecer un criterio explícito para detectar puntos de no convexidad. Finalmente formulamos un esquema numérico de captura de ondas de choque basado en la descomposición local en campos característicos propuesta y presentamos ejemplos numéricos en una y dos dimensiones.

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Miércoles, 6 de mayo

Una breve historia de los agujeros negros: de las estrellas oscuras a las Teorías de Supercuerdas

Prof. Tomás Ortín

Instituto de Física Teórica (UAM/CSIC)

Abstract

En esta charla repasaré desde un punto de vista pedagógico la historia del concepto de agujero negro a través de las teorías fundamentales de la Física desde la Física Newtoniana a las Teorías de Supercuerdas.

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Miércoles, 13 de mayo

Phantom traffic jams and jamitons: On self substaining traffic shocks

Prof. Rodolfo Rubén Rosales

Department of Mathematics (MIT)

Abstract

We find and an analogy between continuum models for traffic flow and reacting gas dynamics, and exploit it to obtain a theory for fully developed phantom jams in roadways. Phantom traffic jams arise without any apparent cause in many roadways when the traffic density is high enough. In the context of inviscid second order continuum models for traffic flows, this phenomena has been associated with a (linear) instability of the uniform density solution. We show that, under these circumnstances, the instability saturates into a self-sustaining upstream traveling wave with an embeddeed shock: the jamiton. These waves are mathematically analogous to Chapman-Jouguet Detonations (CJD) in reacting gas dynamics, which consist of a shock with an attached exothermic reaction zone, isolated from the rest of the flow by a sonic point (event-horizon). Consistent with recent experimental observations from a periodic roadway (Sugiyama et al. New Journal of Physics, 10, 2008), numerical calculations show that these nonlinear traveling waves are attracting solutions, with the time evolution of the system converging towards a jamiton dominated configuration.

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Miércoles, 20 de mayo

Numerical simulations for the Early Universe

Prof. Margarita García Pérez

Instituto de Física Teórica (UAM/CSIC)

Abstract

Real-time numerical simulations are required to deal with the out-of-equilibrium strongly coupled processes taking place in the early Universe. In this talk I will review the numerical approach and some of the results obtained in this context. As a case example, I will focus on discussing a recent proposal for the generation of primordial helical magnetic fields that could give rise to the large scale microgauss fields observed today in galaxies and clusters of galaxies.

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Miércoles, 27 de mayo

Non-ergodicity in Wang-Swenden-Kotecky Monte Carlo dynamics

Prof. Jesús Salas

Instituto Gregorio Millán (UC3M)

Abstract

Markov Chain Monte Carlo simulations have become a very important tool to investigate critical phenomena in Statistical Mechanics and Lattice Field Theory. Indeed, we should require some properties to the algorithm in order to ensure that it converges to the desired probability distribution. The main goal of this talk is to show that the well-known Wang-Swensden-Kotecky (WSK) algorithm for the 4-state Potts antiferromagnet at zero temperature on a triangular lattice with periodic boundary conditions is not ergodic (and hence, it is not a legal algorithm). I will introduce all background concepts (e.g., the q-state Potts model, Markov Chain Monte Carlo algorithms, and the WSK algorithm) before sketching the main ideas leading to the proof of my claim.

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Miércoles, 3 de junio

Kinetic theory and hydrodynamics of Bloch oscillations in nanostructures

Prof. Luis L. Bonilla

Instituto Gregorio Millán (UC3M)

Abstract

Bloch oscillations (BO) are coherent oscillations of the electron position inside energy bands of a crystal under an applied constant electric field. Their frequency is proportional to the field F and to the lattice constant l: ω_B = e F l/h_bar. Zener (1934) was the first to predict BO, which are an immediate consequence of the Bloch theorem in quantum mechanics. Electron scattering (with phonons, impurities, etc.) damps BO very rapidly for natural crystals, and damped BO were not observed until 1992 (in semiconductor superlattices, SL [1]). Since then, damped BO have been measured in many other artificial periodic structures such as ultracold atoms [2] or Bose-Einstein condensates [3] in optical lattices, BO of photons in optical waveguides [4], etc. Besides their interest for theoretical physics, BO have attracted great attention because of their potential for designing infrared detectors, emitters or lasers which can be tuned in the Terahertz frequency range simply by varying the applied electric field [5].

In dc voltage biased semiconductor SL, there are stable self-sustained current oscillations in the Gigahertz range due to a periodic nucleation of electric field pulses in the injector contact and their motion towards the collector [6]. This Gunn-type instability is believed to be responsible for destroying the BO although no one has produced a calculation to prove this belief true. Part of the problem is that BO disappear in the hydrodynamic regime of the usual Boltzmann-type kinetic theory for electronic transport in SL. Recently, we have proposed a Boltzmann-Poisson- BGK model with inelastic collisions for electron transport in one-dimensional SL. Using novel singular perturbation theory, this model allows us to derive a hydrodynamic regime of coupled equations for the slow envelope of the Bloch oscillations, the electron density and the electric field. For small oscillation amplitudes, a convective complex evolution equation for the amplitude provides a criterion for damping or sustainability of Bloch oscillations. Future work may explore the question of how to get a gain under appropriate ac+dc voltage bias.

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Miércoles, 10 de junio

Perturbaciones hidrodinámicas detrás de ondas de choque corrugadas

Prof. Juan Gustavo Wouchuk

E.T.S.I.Industriales (U.C.L.M. Ciudad Real)

Abstract

Se presenta un breve panorama de los flujos hidrodinámicos que se generan detrás de ondas de choque y rarefacción ligeramente corrugadas. Dichos flujos son habituales en situaciones donde se entrega energía de forma rápida y concentrada de forma tal que la materia pueda considerarse en estado fluido. En tales experimentos es habitual la generación de fuertes ondas de compresión u ondas de choque y la materia puede alcanzar condiciones extremas de densidad, presión y temperatura [1,2,3]. La compresibilidad del medio resulta ser un ingrediente importante a la hora de modelar los flujos resultantes.

Las ondas de choque generadas tendrán por lo general, perturbaciones de forma y los flujos hidrodinámicos correspondientes distan mucho de poder describirse con modelos unidimensionales.

Dichas situaciones se dan naturalmente en diversos contextos: explosión de supernovas, experimentos en tubos de choque y en los experimentos de Fusión por Confinamiento Inercial (FCI) [2,3]. En los experimentos de FCI cobra particular importancia la denominada inestabilidad de Richtmyer-Meshkov [4,5], de la que se dará una brevísima pincelada. Se analizará brevemente el *state of the art* de los flujos relacionados con la inestabilidad de Richtmyer-Meshkov.

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Miércoles ,17 de junio

Modelos Matemáticos de la Actividad Eléctrica Cardiaca

Felipe Alonso Atienza

Universidad Rey Juan Carlos

Abstract

Basados en la conjunción de ideas e hipótesis de campos diversos de la ciencia, tales como la biofísica, la ingeniería, las matemáticas y la cardiología, los modelos electrofisiológicos tienen como objetivo fundamental emular y de este modo analizar de forma controlada el comportamiento eléctrico del tejido cardiaco. Desde el trabajo pionero de los británicos Alan L. Hodking y Andrew F. Huxley en 1952, muchas aportaciones se han hecho en el campo del modelado. Actualmente se cuenta con modelos que describen los procesos electrofisiológicos involucrados en la generación y propagación del impulso eléctrico en el miocardio a distintas escalas espaciales, en respuesta a necesidades de investigación distintas. A nivel microscópico se tienen modelos de de canales iónicos y células aisladas. A nivel macroscópico existen modelos de tejidos e incluso de órganos. Así, es posible estudiar, por ejemplo, los efectos de mutaciones hereditarias tanto a nivel celular como a nivel de órganos, generando consecuentemente conclusiones a niveles distintos. En este seminario se describen brevemente los distintos modelos matemáticos que describen la actividad eléctrica cardiaca desarrollados por la comunidad científica siguiendo una perspectiva histórica, haciendo especial hincapié en las aportaciones del autor en este campo.

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Jueves, 18 de junio

Transient laminar opposing mixed convection in a differentially and asymmetrically heated vertical channel of finite length

Prof. César Treviño

Universidad Nacional Autónoma de México

Abstract

In this talk, the transient laminar mixed convection in an differentially heated finite length vertical channel subject to an opposing buoyancy is investigated by solving the unsteady two-dimensional Navier-Stokes and energy equations. Results are particularly presented to illustrate the effects of buoyancy strength or Richardson and Reynolds numbers on the overall flow structure and the nondimensional heat flux (Nusselt number) from the heated surface. Final steady or oscillatory flow response is obtained, depending on the Reynolds and Richardson numbers. The critical value of the buoyancy strength between the two regimes strongly depends on the value of the Reynolds number. The effect of the heat losses to the channel walls is also studied in this work. For relatively large values of the Richardson number, for a given Reynolds number, numerical results show that by increasing the heat losses to the channel walls, the flow structure changes from a multi-spectral flow response to an harmonic flow with a well defined oscillation frequency. The results for the cases of asymmetric and symmetric heating are presented.

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Miércoles, 24 de junio

Photoexcited superlattices as constrained excitable media: Motion of dipole domains and current self-oscillations

José Ignacio Arana

Grupo de Modelización, Simulación Numérica y Matemática Industrial (UC3M)

Abstract

Vertical electronic transport in undoped, photoexcited and voltage biased $Al_xGa_{1-x}As/GaAs$ superlattices is investigated on the basis of a spatially-discrete sequential-resonant-tunneling model governed by differential-difference equations. The recombination, drift velocity and diffusion coefficients are calculated numerically as functions of the electric field according to the overlap of the electron wave functions and microscopic scattering process.

At constant current bias and depending on the laser intensity, the model equations resemble those of the FitzHugh-Nagumo (FHN) model of nerve conduction. Depending on parameter values, the dynamics may be excitable or oscillatory, and wave fronts, pulses and wave trains are among attractors. Asymptotic approximations of these different waves need to go one order beyond those develop for the spatially discrete FHN model in order to agree with the numerical simulations. There are other waves, pulses moving against the electron flow, which are qualitatively different from the FHN ones.

Under dc voltage bias our system may have excitable or oscillatory dynamics but such dynamics is constrained by the requirement that the area under the electric field should be a constant. For large enough voltage, there may appear self-sustained oscillations of the current due to charge dipole waves which are pulses of the electric field. Besides self-oscillations of Gunn-type due to dipole creation at the injector, there are novel oscillations due to repeated homogeneous nucleation of opposite-moving dipole pairs inside the sample. Some of these oscillations are weakly chaotic as they have a positive Lyapunov exponent.

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Miércoles, 7 de octubre

An invitation to collaborate: One-dimensional models for cardiac arrhythmias

Prof. David G. Schaeffer

Duke University

Abstract

In electrocardiology, the term action potential refers to the behavior that, in response to a brief stimulus, the electrical potential across cardiac cell walls is elevated for an extended period. The duration of action potentials under periodic pacing is an important quantity clinically, physiologically, and mathematically. At slow to moderate pacing rates, every stimulus produces an action potential of the same duration, but at high pacing rates cardiac tissue often undergoes a bifurcation to what is called *alternans*: i.e., uniform APD's are replaced by an alternation between short and long action potentials. In a single cell or a small piece of cardiac tissue, this bifurcation is a familiar period-doubling bifurcation, but when propagation effects are important the nature of the bifurcation to alternans is far from clear, even in problems with just one space dimension. For example, the short/long alternation may suffer phase reversals at various locations in the tissue. This behavior, known as *discordant* alternans, is considered to be a precursor to ventricular fibrillation.

Mathematically, these phenomena are governed by a system of reaction-diffusion equations. Echebarria and Karma proposed greatly simplified description of them, a modulation equation for a single unknown. Qualitatively, the bifurcations of the modulation equation match those of the full system, but quantitatively the discrepancies are rather significant. In the lecture I will summarize the general context and propose some specific problems.

These problems are directed towards understanding the behavior of solutions of the full system of reaction-diffusion equations, if possible building on the framework provided by the modulation equation. I hope others may find these problems attractive; I am eager to discuss them.

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Miércoles, 18 de noviembre

Bifurcation in the Echebarría-Karma modulation equation for cardiac arrhythmias

Prof. David G. Schaeffer

Duke University

Abstract

Alternans, the simplest cardiac arrhythmia, is considered to be a precursor of fibrillation, possibly leading to sudden cardiac death. This term refers to behavior in which, under uniform periodic pacing, the response of the heart alternates between short and long action potentials. Moreover, in extended tissue, the phase of the short-long alternation varies with both position and time. The full mathematical description of these phenomena via reaction-diffusion PDE is difficult to analyze. A more tractable approximation-the Echebarría-Karma modulation equation-captures the dynamics at least qualitatively. Solutions of this equation are vulnerable to both steady and time-dependent instabilities. This lecture will focus on the bifurcation phenomena that result from the interaction of these two instabilities.

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Viernes, 4 de diciembre

Monte Carlo simulations of (quasi) constrained ensembles

Prof. Víctor Martín-Mayor

Universidad Complutense de Madrid

Abstract

The standard Monte Carlo simulation of systems displaing metastability is very inefficient. The standard example is that of first-order phase transitions, but metastibility hampers the simulation of many complex systems (spin glasses, structural glasses, lattice polymers,...). One may use constrained statistical ensembles in order to guide the simulation inside those rare but crucial regions were it does not want to get into. Typical implementations of this idea, such as Multicanonical or Wang-Landau simulations, require the system to perform a one-dimensional in the so-called reaction coordinate space. This random-walk is strongly non-Markovian, and does suffer from exponential critical slowing down. Here we propose a different approache. We combine a generalization of Lustig's microcanonical Monte Carlo, with a fluctuation-dissipation formalism. Thermodynamic integration allows for an accurate reconstruction of the effective potential. Cluster algorithms work fine within this framework. This strategy outperforms random-walks methods in the simulation of disordered systems. The presented work has been (mostly) performed in collaboration [1-5].

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