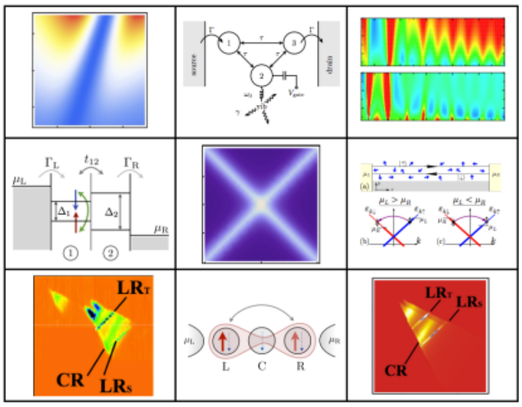

SEXTO ENCUENTRO DE LA RED DE FÍSICA DE SISTEMAS FUERA DEL EQUILIBRIO:

Nonlinear transport, dynamics and fluctuations in condensed matter physics

Madrid

20–22 de noviembre de 2012

Martes 20 de noviembre

09:30-10:00 Presentación

Chairman: Ignacio Pagonabarraga

10:00-10:30 Manuel García-Villalba
Some aspects of the interaction between turbulent flow and finite-size particles.

10:30-11:00 Filippo Terragni
Efficient simulation of nonlinear unsteady problems.

11:00-11:30 Café

11:30-12:00 Pablo Maynar
Linear hydrodynamics for driven granular gases.

12:00-12:30 María Isabel García de Soria
Fluctuaciones de la energía interna para un gas granular en el estado de flujo tangencial uniforme.

12:30-13:00 Iker Zurigel
Flow of sheep through a bottleneck. Effect of the presence of an obstacle.

13:00-15:00 Comida

Chairwoman: Ana Carpio

15:00-15:30 Antonio Prados
Mechanical unzipping of biomolecules: a simple model.

15:30-15:50 David Rodríguez Espeso
Cellular differentiation in biofilms.

15:50-16:10 Francisco Alarcón
Collective motion in squirmer suspensions.

16:10-16:30 Mario Durán Camejo
Simulation of a stochastically and thermophoretically driven agglomeration process.

16:30-17:00 Café

17:00-17:20 Paolo Malgaretti
Cooperative rectification in confined geometries.

17:20-17:40 Moisés García Chamorro
Transport properties for driven granular fluids in situations close to steady homogeneous states.

17:40-18:00 Miguel Ángel G. Maestre
Janus fluid with fixed patch orientations: theory and simulations.

Miércoles 21 de noviembre

Chairman: Luis L. Bonilla

09:30-10:00 Manuel Arias Zugasti
Calculation of Detailed Multicomponent Diffusion Coefficients.

10:00-10:30 José M. Ortiz de Zárate
Correlaciones espaciales de las fluctuaciones de la concentración en problemas de reacción-difusión por el algoritmo de Gillespie.

10:30-11:00 Sigmund Kohler
Steady-State Coherent Transfer by Adiabatic Passage.

11:00-11:30 Café

11:30-12:00 Mariano Álvaro
Bloch and Gunn type oscillations in semiconductor superlattices.

12:00-12:20 Antonio A. Valido Flores
Tripartite Gaussian entanglement in non-resonant harmonic oscillators at non-equilibrium conditions.

12:20-12:40 Idulfo Arrocha
Spectral Modeling of The Dynamics of Optically Injected One-Dimensional Currents.

12:40-13:00 Carlos E. Chávez
Avoiding the Inverse Crime in the Inverse Problem of Electrocardiography.

13:00-15:00 Comida

Chairwoman: Gloria Platero

15:00-15:30 Diego Frustaglia
Engineering geometrical spin phases in mesoscopic systems.

15:30-15:50 Fernando Domínguez
Dynamical detection of Majorana fermions in current-biased nanowires.

15:50-16:10 Álvaro Gómez León
Ac magnetic fields and qubits.

16:10-16:30 Robert Hussein
Coherent quantum ratchets driven by tunnel oscillations: Fluctuations and correlations.

16:30-17:00 Café

17:00-17:30 Rafael Molina
Time-dependent wave packet simulations of transport through Aharanov-Bohm interferometers.

17:30-18:00 Farkhad Aliev
Controlling shot noise in double barrier epitaxial magnetic tunnel junctions.

21:00 Cena del congreso
Restaurante La Ópera de Madrid en la **calle Amnistía 5 a las 21 horas** (cerca del Teatro Real, metro Ópera).

Jueves 22 de noviembre

Chairman: Sigmund Kohler

10:00-10:30 Juan J. García Ripoll
Driven quantum circuits.

10:30-11:00 Rafael Sánchez
Rectification of thermal fluctuations in electrical conductors.

11:00-11:30 Café

11:30-12:00 Rosa López
Scattering theory of nonlinear thermoelectric transport.

12:00-12:30 Salvador Miret-Artes
Incoherent tunneling surface diffusion for interacting adsorbates.

12:30-13:00 Clausura

13:00-15:00 Comida

Some aspects of the interaction between turbulent flow and finite-size particles

Manuel García-Villalba,[1] Aman G. Kidanemariam,[2] and Markus Uhlmann[2]

[1] *Universidad Carlos III de Madrid, Butarque 15; 28911 Leganés, Madrid*

[2] *Institute for Hydromechanics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany*

In this talk we will present results of a direct numerical simulation of dilute turbulent particulate flow in a vertical plane channel, fully resolving the phase interfaces. We observe the formation of large-scale columnar-like structures which are only marginally decorrelated in the longitudinal direction. Voronoi analysis of the spatial particle distribution shows that the state of the dispersed phase can be characterized as slightly more ordered than random tending towards a homogeneous spatial distribution. It is also found that the p.d.f.'s of Lagrangian particle accelerations for wall-normal and spanwise directions follow a lognormal distribution as observed in previous experiments of homogeneous flows. The streamwise component deviates from this law presenting significant skewness. Finally, a statistical analysis of the flow in the near field around the particles reveals that particle wakes present two regions, a near wake where the velocity deficit decays as x^{-1} and a far wake with a decay of approximately x^{-2}.

Efficient simulation of nonlinear unsteady problems

Filippo Terragni[1] and José Manuel Vega[2]

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[2] *Universidad Politécnica de Madrid, Plaza Cardenal Cisneros 3, 28040 Madrid, España*

Various ideas and methods involving local proper orthogonal decomposition (POD) and Galerkin projection are presented aiming at efficiently simulating nonlinear dynamics in time dependent parabolic problems.

The proposed approach combines, in interspersed time intervals, short runs with a given numerical solver and the integration of reduced order models constructed by expanding the solution of the problem into appropriate POD modes and Galerkin projecting some evolution equations onto that linear basis. The procedure is adaptive, since the POD basis is locally updated according to the time-varying dynamics, and does not exhibit truncation instabilities. Results are illustrated for the unsteady laminar flow in a 2D driven cavity.

Some properties concerning the weak dependence of the POD modes on time and possible parameters in the problem are also exploited, in order to show the great flexibility of the POD basis computation. As one possible application, the approximation of complex bifurcation diagrams can be performed with high efficiency, which is shown for the 1D complex Ginzburg-Landau equation.

Linear hydrodynamics for driven granular gases

P. Maynar,[1] M.I. García de Soria,[1] and E. Trizac[1]
[1] *Universidad de Sevilla, Avenida de Reina Mercedes S/N, Facultad de Física, Departamento FAMN, Área de Física Teórica*

We study the dynamics of a granular gas heated by the stochastic thermostat. From a Boltzmann description, we derive the hydrodynamic equations for small perturbations around the stationary state that is reached in the long time limit. Transport coefficients are identified as Green-Kubo formulas obtaining explicit expressions as a function of the inelasticity and the spacial dimension. It is seen that, although we are considering linear response around the stationary state, the dynamics depend on the most general hydrodynamic state through which the stationary state is reached. This state is not stationary and is described at a kinetic level by a two-parameter scaling distribution function [1].

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[1] M. I. García de Soria, P. Maynar, and E. Trizac, Phys. Rev. E **85**, 051301 (2012)

Fluctuaciones de la energía interna para un gas granular en el estado de flujo tangencial uniforme

J. Javier Brey,[1] M. I. García de Soria ,[1] and P. Maynar[1]

[1] *Universidad de Sevilla, Avenida Reina Mercedes s/n. Facultad de Física. Departamento de FAMN. Área de Física Teórica.*

Las propiedades estocásticas de la energía interna total para un gas granular en el estado de flujo tangencial uniforme han sido estudiadas. Hemos extendido una reciente teoría para las fluctuaciones alrededor del estado de enfriamiento homogéneo en analogía con los fluidos moleculares. Las predicciones teóricas se han comparado con simulaciones de Dinámica Molecular encontrándose un buen acuerdo en el límite de baja inelasticidad. Por otra parte, hemos abordado el mismo problema usando Teoría Cinética y las diferencias serán discutidas.

Flow of sheep through a bottleneck. Effect of the presence of an obstacle

Iker Zuriguel[1] and Ángel Garcimartín[1]

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Universidad de Navarra, Edificio de los Castaños,
C/Irunlarrea s/n, Aptdo. 177, 31080 Pamplona

There are times when mobs have to pass through a bottleneck, such in the case of an emergency exit. If panic seizes the crowd, a jamming can obstruct the way out. This phenomenon displays many features that are also observed with inert particles (e.g. sand, cereal) when they choke the exit of a silo or clog pipe. Recent research has lead to the discovery that an obstacle before the exit of a silo relieves the pressure near the orifice and the jamming probability decreases [1]. Although there are some works that suggest that this method is also valid to reduce the likelihood of clogging for live beings, it is a matter of fact that the procedure has not been definitively proved.

In this talk, recent experimental results of the flow of sheep through bottlenecks will be presented and compared with already existent computer simulations. In addition an analogy with the case of silo clogging will be introduced revealing the strong connection between these two apparently different scenarios.

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[1] I. Zuriguel, A. Janda, A. Garcimartín, C. Lozano, R. Arévalo, and D. Maza, Phys. Rev. Lett. **107**, 278001 (2011).

Mechanical unzipping of biomolecules: a simple model

A. Prados,[1] A Carpio,[2] and L.L. Bonilla[3]

[1] *Física Teórica, Facultad de Física, Universidad de Sevilla, Apartado de Correos 1065, E-41080 Sevilla*

[2] *Departamento de Matematica Aplicada, Universidad Complutense, Madrid 28040*

[3] *Universidad Carlos III Madrid, Av. Universidad 30, 28911, Leganés, Madrid*

We propose a simple model for the mechanical unzipping of biomolecules. It comprises a macroscopic (elastic) degree of freedom, modelled by a one-dimensional oscillator, and some internal degrees of freedom, modelled by Glauber spins with nearest-neighbour interaction and a coupling constant proportional to the oscillator position. This spin-oscillator coupling gives rise to a first-order phase transition when a mechanical force F is applied to the system: there is a critical force F_c at which the equilibrium oscillator rest position abruptly changes. If the system is pulled (increasing F), the oscillator position increases discontinuously at a certain value of the force $F_+ > F_c$, which depends on the pulling rate. Afterwards, in the pushing back experiment (decreasing F) with the same rate, the oscillator position decreases discontinuously at a value of the force $F_- < F_c$, and hysteresis shows up. Processes at constant load F close to the critical value F_c are also discussed, in which the system stochastically jumps between the two (stable and metastable) possible rest positions of the oscillator.

The system behaviour is analogous to that of biomolecules in real experiments, and it stems from the existence of the first order phase transition and its associated region of metastability. This phase transition is a consequence of the spin-oscillator coupling, which introduces an effectively long-range interaction among the spins. Similar hidden 1d long range effective correlations are present in real biomolecules.

[1] A. Prados, A. Carpio, and L. L. Bonilla, Phys. Rev. E **86**, 021919 (2012).

Cellular differentiation in biofilms

David Rodriguez [1] and A. Carpio[2]

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[2] *Departamento de Matematica Aplicada,*
Universidad Complutense, Madrid 28040.

Bacterial strains have been observed to live in nature mostly forming self-produced extracellular matrix encased clusters called biofilms. These aggregations generate molecular signals as a cell-cell communication mechanisms to activate several gene expressions that unleash different survival mechanisms according with environmental conditions. These communication processes, which are still poorly understood, might be one of the key issues to clarify about the different community behaviours observed in bacterial colonies.

A 2D stochastic model for reproduction and differentiation based on molecular signalling is proposed. An initial cluster of biofilm adhered onto an agar - gel surface and exposed to the atmosphere is set to evolve freely. Diffusion of signals and metabolic reactions generated inside the biofilm by bacteria make the system to evolve dynamically, triggering the differentiation of the original cells into new well differentiated subtypes of cells that affect the reproduction rate and geometry of the overall system.

Simulations show that the chemical production of molecular signals together with a balanced reproduction process and the presence of concentration gradients transported by diffusion mechanisms lead to bacterial distributions similar to those observed experimentally.

Collective motion in squirmer suspensions

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Universitat de Barcelona, Marti i Franques, 1, 08028 Barcelona, SPAIN

Collective motion in out-of-equilibrium systems composed of a large number of interacting individuals can be seen as a self-assembly phenomenon, which gives rise to intriguing emergent patterns. Due to their kinetic origin, the spontaneous structures that these system give rise to, are far more complex than equilibrium self-assembly in traditional metals, ceramics and polymers, with many levels of functionality, hierarchical organization, and compartmentalization [1]. Non-equilibrium materials must actively consume energy and remain out of equilibrium to support their structural complexity and functional diversity [2, 3]. In Biology flocking birds, fish schools, and insect swarms constitute examples of collective motion that plays a role in a range of problems, such as spreading of diseases [4]. In particular, micro-swimmer suspensions at low Reynolds number, such as bacterial colonies [5], exhibit fascinating collective behavior, including the possibility of non-equilibrium phase transitions between disordered and ordered states, novel long-range correlations, and pattern formation on mesoscopic scales [6]. Using a simple model in which the effect of the internal metabolism of the micro-organism can be described through the effective fluid flow the particle generates on its surface, making use of the squirmer model [7], and adding a Lennard-Jones (LJ) interaction between the swimmers as a model of the communication between the micro-organisms, we have fully characterized the clusters and the collective coherent orientation of the swimmers movement which emerge for some cases. We analyze the transition of the spontaneously formed structures as a function of the relative strength of the LJ interactions and hydrodynamic interactions.

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[1] F. Li , D. P. Josephson, A. Stein: Angew. Chem. Int. Ed **50**, 360 (2011).
[2] A. Snezhko, I.S. Aranson: Nature Mater. **10**, 698 (2011).
[3] S.C. Glotzer, M.G. Solomon: Nature Mater. **6**, 557 (2007).
[4] H.P. Zhang, A. Be´ er, E.-L. Florin, H.L. Swinney:PNAS **107**, 13626 (2010).
[5] C. Dombrowski, L. Cisneros, L. Chatkaew, R. Goldstein, J. Kessler, *Phys. Rev. Lett.* **93**, 098103 (2004).
[6] A. Baskaran and M.C. Marchetti, *Proc. Natl Acad. Sci.* **106**, 37 (2009).
[7] J.R. Blake, *Journal of Fluid Mechanics* **46**, 01 (1971).

Simulation of a stochastically and thermophoretically driven agglomeration process

Mario D. Camejo,[1] David R. Espeso,[1] and Luis L. Bonilla[1]

[1] *Universidad Carlos III de Madrid. Av. de la Universidad 30, 28911 Leganés, España.*

Agglomeration processes take place in many different scenarios concerning colloid and aerosol formation. As part of a work of heterogeneous and homogeneous condensation and subsequent deposition on boundary-layer flows, we have tackled the creation of fractal-like soot agglomerates. Process of agglomeration has been classically faced by stochastic simulations. But Brownian forces that are very important during the initial stages tends to reduce significantly with growth. At that time thermophoretic forces are expected to have the most important role and will therefore affect the geometric structure of the agglomerate. We propose a model where both, stochastic and thermophoretic forces, drive the agglomeration process. As we are talking about primary particles in the order of 10-50 nm, the free molecular regime has been considered.

The agglomeration process is simulated by applying a random-diffusive mixed procedure. It consists in calculate the mean translational diffusion coefficient of the agglomerate anytime a new bond is formed. The ratio of the diffusion coefficients of the agglomerate and the single particle controls the displacement of the agglomerate. In addition to stochastic motion we consider the thermophoresis calculating the net force on the agglomerate at each time step.

The process is run for different residence times, obtaining the parameters characterizing the agglomerate geometry and the thermophoretic velocities.

Cooperative rectification in confined geometries

Paolo Malgaretti,[1] Ignacio Pagonabarraga,[1] and Miguel Rubi[1]
[1] *Universitat de Barcelona, Carrer Martí i Franques 1*

We analyze the rectified motion of a Brownian particle in a confined environment. We show the emergence of strong cooperativity between the inherent rectification of the ratchet mechanism and the entropic bias of the fluctuations caused by spatial confinement. Net particle transport may develop even in situations where separately the ratchet and the geometric restrictions do not give rise to particle motion. The combined rectification effects can lead to bidirectional transport depending on particle size, resulting in a new route for segregation. The reported mechanism can be used to control transport in mesostructures and nanodevices in which particles move in a reduced space.

Transport properties for driven granular fluids in situations close to steady homogeneous states

Moisés G. Chamorro,[1] V. Garzó, and F. Vega Reyes

[1] *Departamento de Física, Universidad de Extremadura, Avda Elvas s.n.*

The transport coefficients of a granular fluid driven by a stochastic bath with friction are obtained by solving the inelastic Enskog kinetic equation from the Chapman-Enskog method. The heat and momentum fluxes as well as the cooling rate are determined to first order in the deviations of the hydrodynamic field gradients from their values in the homogeneous steady state. Since the collisional cooling cannot be compensated locally for the heat produced by the external driving force, the reference distribution $f^{(0)}$ (zeroth-order approximation) depends on time through its dependence on temperature. This fact gives rise to conceptual and practical difficulties not present in previous analysis where $f^{(0)}$ was assumed to be stationary. On the other hand, to simplify the analysis and given that we are interested in computing transport in the first order of deviations from the reference state, the steady-state conditions are considered to get explicit forms for the transport coefficients and the cooling rate. A comparison with recent molecular dynamics simulations for driven granular fluids shows an excellent agreement for the kinematic viscosity although some discrepancies are observed for the longitudinal viscosity and the thermal diffusivity at large densities. Finally, a linear stability analysis of the hydrodynamic equations with respect to the homogeneous steady state is performed. As expected, no instabilities are found thanks to the presence of the external bath.

Janus fluid with fixed patch orientations: theory and simulations

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We study thermophysical properties of a Janus fluid with constrained orientations, using analytical techniques and numerical simulations. The Janus character is modeled by means of a Kern-Frenkel potential where each sphere has one hemisphere of square-well and the other of hard-sphere character. The orientational constraint is enforced by assuming that each hemisphere can only point either North or South with equal probability. The analytical approach hinges on a mapping of the above Janus fluid with up-down constrained orientations into a binary mixture interacting via a "quasi" isotropic potential. The anisotropic nature of the original Kern-Frenkel potential is reflected by the non-symmetry in the interactions occurring between the unlike components of the mixture. A rational function approximation extending the corresponding symmetric case is obtained in sticky limit, where the square-well becomes infinitely narrow and deep, and allows a fully analytical approach. Notwithstanding the rather drastic approximations in the analytical theory, this is shown to provide a rather precise estimate of the structural and thermodynamical properties of the original Janus fluid.

Calculation of Detailed Multicomponent Diffusion Coefficients

Manuel Arias Zugasti,[1] Pedro Luis García-Ybarra,[1] and Jose Luis Castillo Gimeno[1]
[1] *UNED, Paseo de la Senda del Rey 9, 28040, Madrid*

The structure and stability of flame fronts depend, to a great extent, on the diffusion properties of the chemical species at the flame front. Whereas chemical kinetics effects have been extensively analyzed in recent combustion studies, the detailed diffusive transport, which is equally important regarding flame front properties, has received comparatively much less attention.

In the present work the calculation of the transport properties of a multicomponent mixture of ideal gases is revisited. New analytical relations are formally derived from the kinetic theory of gases for a mixture of an arbitrary number of components of arbitrary molecular weights and interaction potentials.

The proposed method provides a valuable tool for the calculation of transport properties of multicomponent ideal gases with a large number of chemical species, as is usually the case in combustion.

Correlaciones espaciales de las fluctuaciones de la concentración en problemas de reacción-difusión por el algoritmo de Gillespie

Jorge Luis Hita[1] and José M. Ortiz de Zárate [1]

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Steady-State Coherent Transfer by Adiabatic Passage

Jan Huneke,[1] Gloria Platero,[1] and Sigmund Kohler[1]

[1] *Instituto de Ciencia de Materiales de Madrid (CSIC),*
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We propose steady-state electron transport based on coherent transfer by adiabatic passage (CTAP) in a linearly arranged triple quantum dot with leads attached to the outer dots. Its main feature is repeated steering of single electrons from the first dot to the last dot without relevant occupation of the middle dot. The coupling to leads enables a steady-state current, whose shot noise is significantly suppressed provided that the CTAP protocol performs properly. This represents an indication for the direct transfer between spatially separated dots and, thus, may resolve the problem of finding experimental evidence for the non-occupation of the middle dot.

Bloch and Gunn type oscillations in semiconductor superlattices

M. Álvaro,[1] L.L. Bonilla,[1] and M. Carretero[1]

[1] *Universidad Carlos III Madrid, Av. Universidad 30, 28911, Leganés, Madrid*

Bloch oscillations are potentially important to design infrared detectors, emitters, or lasers which can be tuned in the terahertz frequency range simply varying the applied electric field. We analyze theoretically Bloch oscillations in a doped semiconductor superlattice with long scattering times when the damping of Bloch oscillations is small and convective nonlinearities may compensate it. In this case, Bloch oscillations may persist in the hydrodynamic regime and, for low enough temperatures, they may coexist with Gunn type oscillations. To demonstrate this, we propose a Boltzmann-Poisson transport model of miniband superlattices with inelastic collisions and we derive, by singular perturbation methods, hydrodynamic equations for electron density, electric field, and the complex amplitude of the Bloch oscillations. We solve numerically the hydrodynamic equations for a dc voltage biased superlattice with appropriate boundary conditions. For appropriate parameter ranges the results show stable inhomogeneous Bloch oscillations coexisting with Gunn type oscillations. These Bloch oscillations disappear as scattering times become sufficiently short. For larger temperatures (300 K) there are only Bloch oscillations with inhomogeneous stationary amplitude and electric field profiles. This novel finding of coexisting Bloch oscillations of about 0.36 THz and 13.8 GHz Gunn type oscillations is somewhat unexpected as it is usually assumed that Gunn type oscillations have to be eliminated to get Bloch oscillations.

Tripartite Gaussian entanglement in non-resonant harmonic oscillators at non-equilibrium conditions

Antonio A. Valido Flores[1]

[1] *Universidad de La Laguna, Av. Astrofísico Francisco Sánchez s/n, La Laguna, Santa Cruz de Tenerife, España*

Over the last years, multipartite quantum correlations have been extensively studied from the theoretical point of view, and have also been object of interest in many experiments with photons, trapped ions, cold atoms and nanomechanical oscillators. A correct understanding of the effects of decoherence on quantum correlations is of fundamental importance, and in this talk, we present our mean work on this topic. In particular, we address the model of three mechanically interacting harmonic oscillators, each coupled to its own Ohmic bath at a given temperature. We obtain the stationary state of the system within the exact formalism of generalized Langevin equations, and qualitatively study the different types of asymptotic multipartite entanglement. It is important to note that this results apply to any regimen (low or high temperatures and strong or weak dissipation). That development lend us to the mean conclusion of the work: nonequilibrium conditions are detrimental to the creation of tripartite Gaussian entanglement. Moreover, we shed some light over how the asymptotic behaviour of entanglement is affected by the detuning and the coupling among oscillators.

Spectral Modeling of The Dynamics of Optically Injected one-dimensional currents

Idulfo Arrocha,[1] Manuel Carretero,[1] Manuel Kindelan,[1] and Rodolfo R. Rosales[2]

[1]Universidad Carlos III de Madrid, Avda. Universidad 30, 28911 Leganés

[2]Department of Mathematics, MIT, USA

We investigate a phenomenological hydrodynamic model for the charge dynamics of optically injected currents in multiple quantum well structures. The model is described by a coupled system of nonlinear integro-differential equations in two dimensions for the electron density and electron velocity. Looking for plane wave solutions of the model equations makes it possible to simplify the problem to a one-dimensional version, which is simple enough, but contains the main physics of the original one. In fact, the solution of the simplified model shows, not only good qualitative agreement with the solution of the full two-dimensional model, but also quite good quantitative agreement. For the numerical solution of the model, we write the equations in a comoving coordinate system which is solved using spectral methods.

Avoiding the Inverse Crime in the Inverse Problem of Electrocardiography

Carlos E. Chávez,[1] Felipe Alonso-Atienza,[2] and Diego Álvarez[1]

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[2] *Universidad Rey Juan Carlos, Camino del Molino s/n, Fuenlabrada, Madrid*

The Inverse Problem of electrocardiography (IPE) can be summarized as the characterization of the electrical behavior of the heart using measurements obtained by electrodes that are not directly in contact with the cardiac surfaces. Given a data ensemble provided by electrodes, the solution of the IPE requires the design of a mathematical procedure that matches a theoretical model of estimated measurements with that ensemble of data. Earlier tests of the inversion procedure were often made with synthetic data using the same model for computing both predicted and estimated measurements, yielding into an unreal and optimistic result; this is called Inverse Crime. In practice, the test of an inversion process avoiding the Inverse Crime could be done using a model for the numerically produced simulated data and a different one to invert the data. This work shows the behavior of a procedure designed to characterize regions in the heart with a lack of blood supply (ischemia) avoiding the Inverse Crime. Realistics and experimentally supported models constitute the forward procedure (the Luo-Rudy model for the electrical activity and the volume conductor theroy for simulating the electrode measurements) while a simple phenomenological model (the two-current model proposed by Mitchell and Schaeffer) is used during the inversion process.

Engineering geometrical spin phases in mesoscopic systems

D. Frustaglia[1]

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Research on spin geometric (Berry) phases in mesoscopic systems has been active for 20 years already. During this time, several proposals were put forward for the detection of topological effects in spin interferometers subject to magnetic textures, accompanied by several experimental attempts of different success. However, incontrovertible evidence of these effects was found only recently in mesoscopic rings under the action to spin-orbit coupling (Rashba rings), providing a new impulse to the field. Here, after a brief account of previous achievements, we shall discuss some new possibilities for electronic manipulation based on the control of the spin geometric phases in nanodevices as Rashba loops (rings and polygons) subject to additional magnetic fields. Besides, we shall comment on the role played by these geometrical phases for the development of topological superconducting phases in Floquet systems, where Majorana fermions should manifest as edge states.

Dynamical detection of Majorana fermions in current-biased nanowires

Fernando Domínguez,[1] Fabian Hassler,[1] and Gloria Platero[1]
[1] *ICMM CSIC, Sor Juana Inés de la Cruz*

We analyze the current-biased Shapiro experiment in a Josephson junction formed by two one-dimensional nanowires featuring Majorana fermions. Ideally, these junctions are predicted to have an unconventional 4π-periodic Josephson effect and thus only Shapiro steps at even multiples of the driving frequency. Taking additionally into account overlap between the Majorana fermions, due to the finite length of the wire, renders the Josephson junction conventional for any dc-experiments. We show that probing the current-phase relation in a current biased setup dynamically decouples the Majorana fermions. We find that besides the even integer Shapiro steps there are additional steps at odd and fractional values. However, different from the voltage biased case, the even steps dominate for a wide range of parameters even in the case of multiple modes thus giving a clear experimental signature of the presence of Majorana fermions.

Ac magnetic fields and qubits

Álvaro Gómez León[1] and Gloria Platero[1]

[1]*Instituto de Ciencia de Materiales de Madrid (CSIC), Sor Juana Inés de la Cruz, 3, Cantoblanco, 28049, Madrid, Spain*

Quantum systems coupled to periodic ac electric or magnetic fields present new interesting coherence properties not present in the undriven system. We will show that the presence of an external periodic ac magnetic field applied to a two coupled two-level systems, such as a double quantum dot, is able to induce charge localization, spin locking or both, by tuning the ac field parameters, i.e., the frequency, intensity or phase difference, as well as by tuning its polarization.

In contrast with ac electric fields, the possibility of induce dynamical spin locking will allow to freeze the spin projection of the initial state for some values of the parameter space [1, 2]. We show how the symmetries of the Hamiltonian in the presence of the driving field influence the quasi-energy spectrum and how they determine the electronic charge and spin dynamics

Finally we discuss how the application of an ac magnetic field to these systems allows to tune the topological properties for both the adiabatic and the non adiabatic regime [3]. Our results generalize those on geometrical phases for the spin by Berry [4] including the spatial degree of freedom and spatial anisotropy for the magnetic field.

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[1] Charge localization and dynamical spin locking in double quantum dots driven by ac magnetic fields, A. Gómez-León and G. Platero, Phys. Rev. B (Rapid Communications) **84**, 121310 (2011).

[2] Transport blocking and topological phases using ac magnetic fields, A. Gómez-León and G. Platero, Phys. Rev. B **85**, 245319 (2012).

[3] Topological phases in adiabatic and nonadiabatic driven systems, A. Gómez-León and G. Platero, Phys. Rev. B **86**, 115318 (2012).

[4] Quantal Phase Factors Accompanying Adiabatic Changes, M. V. Berry, Proc. R. Soc. Lond. A **392**, 45-57 (1984).

Coherent quantum ratchets driven by tunnel oscillations: Fluctuations and correlations

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We study two capacitively coupled double quantum dots of which one double dot is strongly biased (”drive circuit”), while the other (”ratchet”) is unbiased. Tunnel oscillations in the stationary state of the drive circuit induce a ratchet current, i.e., a dc current in the absence of a net force. Current and noise of this ratchet current are investigated with a quantum master equation by means of the full-counting statistics. We find that whenever the ratchet current is large, it exhibits features of a Poisson process. Analytical expressions for the low-order current cumulants are obtained by eliminating the drive circuit.

Time-dependent wave packet simulations of transport through Aharanov-Bohm interferometers

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We have performed time-dependent wave packet simulations of realistic Aharonov-Bohm (AB) devices with a quantum dot embedded in one of the arms of the interferometer. The AB ring can function as a measurement device for the intrinsic transmission phase through the quantum dot, however, much care has to be taken in analyzing the influence of scattering processes in the junctions of the interferometer arms. We consider a harmonic quantum dot and show how the Darwin-Fock spectrum emerges as a unique pattern in the interference fringes of the AB oscillations.

Controlling shot noise in double barrier epitaxial magnetic tunnel junctions

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We have recently shown that shot noise is an effective tool to study the statistics of electron tunnelling in single and double barrier magnetic tunnel junctions [1–3]. The first part of this talk is intended to provide a pedagogic introduction to shot noise as a tool to investigate photon or electron transport correlations. The second part discusses our recent results on shot noise in epitaxial double barrier magnetic tunnel junctions. We demonstrate that shot noise in Fe/MgO/Fe/MgO/Fe double barrier magnetic tunnel junctions is determined by the barrier asymmetry, the relative magnetic configuration and is influenced by quantum well states in the central layer. The proposed theoretical model of sequential tunnelling through the system, with spin relaxation taken into account, successfully accounts for the experimental observations in the applied bias range, where the influence of tunnelling through barrier defects and resonant states inside the central electrode is negligible. These results open a perspective to engineer fundamental, out of equilibrium, noise mechanisms utilizing hybrid spintronic structures.

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Driven quantum circuits

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In this talk I will present our recent developments in the field of superconducting quantum circuits. In these circuits we can simulate the traditional quantum optics, including two-level systems, harmonic oscillators and dissipations, using only superconducting elements: inductors, capacitors, Josephson junctions, etc. I will focus on tasks related to entanglement generation and squeezing, both in open transmission lines and coupled resonators.

Rectification of thermal fluctuations in electrical conductors

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In electrical circuits hot spots occur naturally at places where energy is dissipated. Here we propose a controlled experiment which can demonstrate the appearance of directed current as a consequence of a hot spot. We investigate transport generated in Coulomb coupled electrical conductors from excess electric or thermal fluctuations at the coupling capacitance.

If one of the conductors supports a bias voltage, out of equilibrium charge fluctuations remove detailed balance in the unbiased system manifested in a drag current. Non linear fluctuation relations can nevertheless be obtained [1].

Coulomb coupled conductors permit separate directions of the heat and current flux [2]. In our model, one of the conductors is connected via only one lead to a hot reservoir. The other conductor connects to two leads. We investigate the minimal conditions needed to generate directed current flow for a system of two quantum dot conductors in which both energy and charge states are quantized. In quantum dots energy to current conversion can be optimal with one electron transferred for every heat quantum given up by the hot reservoir. We discuss the implications in the form of non linear fluctuation relations for heat and charge transfer statistics.

The scalability of the problem to larger systems open to transport is discussed. Chaotic cavity heat engines allow for larger power extraction with a reduced endciency [4].

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Scattering theory of nonlinear thermoelectric transport

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We investigate nonlinear transport properties of quantum conductors in response to both electrical and thermal driving forces. Within scattering approach, we determine the nonequilibrium screening potential of a generic mesoscopic system and find that its response is dictated by particle and entropic injectivities which describe the charge and entropy transfer during transport. We illustrate our model analyzing the voltage and thermal rectification of a resonant tunneling barrier. Importantly, we discuss interaction induced contributions to the thermopower in the presence of large temperature differences.

Incoherent tunneling surface diffusion for interacting adsorbates

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Tunneling surface diffusion of light atoms is analyzed in terms of a master equation restricted to only nearest-neighbors for moderate to high temperatures where incoherent motion is predominantly, that is, above the crossover surface temperature. The observed intermediate scattering function of diffusing H and D atoms on the Pt(111) surface, issue from spin echo measurements, is analyzed in the framework of the so-called bounce technique where analytical expressions can be used. Furthermore, within the so-called two bath model for interacting adsorbates, it is predicted an increasing of the tunneling rates when the coverage is decreased.

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