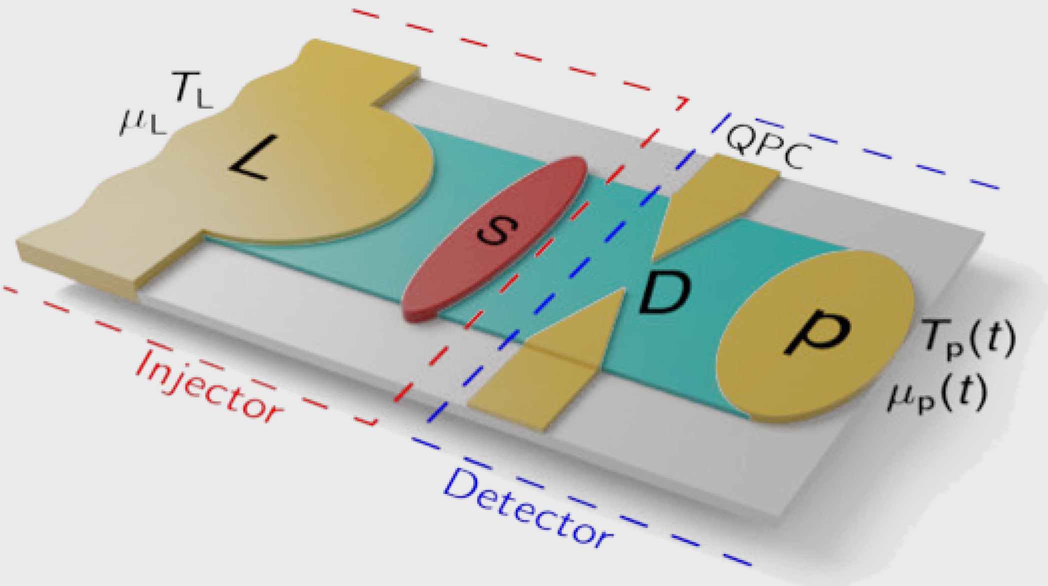
Charge and Energy Noise in ac-driven Conductors and their Detection from Frequency-resolved Potential and Temperature Fluctuations



Title: Charge and Energy Noise in ac-driven Conductors and their Detection from Frequency-resolved Potential and Temperature Fluctuations.
When: Tuesday, December 12, (2017), 12:00.
Place: Department of Theoretical Condensed Matter Physics, Faculty of Science, Module 5, Seminar Room (5th Floor).
Speaker: Janine Splettstoesser, Microtechnology and Nanoscience, Applied Quantum Physics Laboratory Department of Microtechnology and Nanoscience, Chalmers University of Technology, Göteborg, Sweden.

The time-dependent driving of nanoscale conductors allows for the controlled creation of single-electron excitations. This effect has been demonstrated experimentally both by application of time-dependent driving to gates coupled to confined systems, such as quantum dots [1], and by specifically shaped ac-driving of two-dimensional conductors [2,3].
However, the spectral properties of the injected signal are in general not known; moreover, the particle emission goes along with the excitation of electron-hole pairs with some unknown energy distribution. These issues can be addressed by studying fluctuations in the detected currents: not only do such fluctuations provide more insight into how to increase the precision of the single-particle emission, but also they allow for obtaining more information about the character of the emitted signal.
Here, I will present a theoretical study of charge and energy currents and their fluctuations in coherent conductors driven by different types of time-periodic bias voltages, based on a scattering matrix approach [4,5]. Specifically, we investigate the role of electron-like and hole-like excitations created by the driving in the charge

current noise, where they only contribute separately. In contrast, additional features due to electron-hole correlations appear in the energy noise.

We then compare two different types of driving schemes [6], that is for a driven mesoscopic capacitor [1] as well as for a Lorentzian-shaped bias voltage [3], which do not differ in the number of injected particles, but only in their energetic properties.

Finally, I will discuss proposals for the detection of charge and energy noise, either through power fluctuations [4], or via frequency-dependent temperature and electrochemical-potential fluctuations in a probe reservoir [7].

References

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J. Gabelli and B. Reulet, Phys. Rev. B 87, 075403 (2013).

J. Dubois, T. Jullien, F. Portier, P. Roche, A. Cavanna, Y. Jin, W. Wegscheider, P. Roulleau, and D. C. Glattli, Nature 502, 659 (2013).

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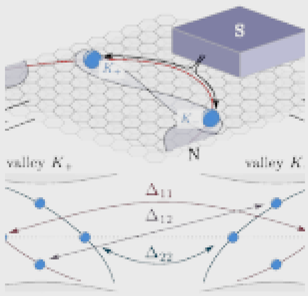
Transport Through Topological Confined States of Matter



Title: Transport Through Topological Confined States of Matter.

When: Monday, January 30, (2017), 12:00.

Place: Departamento de Física Teórica de la Materia Condensada, Facultad Ciencias, Module 5, Seminar Room (5th Floor).

Speaker: Patrik Recher, Technische Universität Braunschweig Institut für Mathematische Physik, Braunschweig, Germany.

In my talk, I will introduce transport calculations through topologically confined states of matter. In graphene and silicene, valley chiral states can be created by a mass domain wall that is tunable by an applied voltage. Contacting these valley chiral states with superconductors, I will discuss novel ways to split spin-entangled Cooper pairs using the valley degree of freedom [1] and to tune the Josephson effect from a 2 π to 4 π phase relation when in addition spin-orbit coupling is present. Further topological confined states of interest are Majorana bound states (MBS) in topological superconductors. I will show that transport through networks of such MBS can be conveniently described using full counting statistics and that unique signatures of MBS are seen in Fano resonances in a setup where the MBS are coupled to a normal metal lead and to a quantum dot.

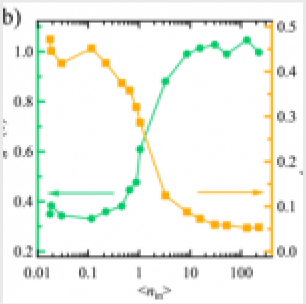
References

A. Schroer, P.G. Silvestrov, and P. Recher, Phys. Rev. B 92, 241404(R) (2015).

More information on IFIMAC Website

A Single-photon Fock State Filter in the Solid State

Title: A Single-photon Fock State Filter in the Solid State.
When: Friday, October 28, (2016), 12:00.
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Module 3, Seminar Room (5th Floor).
Speaker: Carlos Antón Solanas, C2N, CNRS, Université Paris-Saclay, 91460 Marcoussis, France.



One of the major roadblocks to scale optical quantum technologies is the probabilistic operation of quantum optical gates that are based on the coalescence of two indistinguishable photons. A way around this problem is to make use of the single-photon sensitivity of an atomic transition when the atom interacts with only a single mode of the optical field (one dimensional atom case [1]). In such situation, each photon sent on the device interacts with the atom: the first photon is reflected and the second one is transmitted, realizing a deterministic photon router. Such possibility has been investigated in QD-photonic crystal cavities [2], yet in an indirect way since the response was measured in crossed polarization to post-select on photons that have entered the cavity.

In this work, we demonstrate the single-photon filtering by a QD in a micropillar cavity performing as a quasi ideal one dimensional atom [3], see scheme in Fig. 1(a). The device is probed with a pulsed laser and we collect the total reflected signal in the same polarization. As shown in Fig. 1(b), the system presents a nonlinearity threshold for an average incident photon number as low as ~0.1. The g(2)(0) measure of the reflected light evidences that it is mostly constituted by single-photons [80% fraction of single-photons, see Fig. 1(c)] and that the multi-photon component of the field is efficiently suppressed. Three-photon correlation measurements of the reflected signal have been performed to evidence the non-poissonian statistics of the output photons.

References

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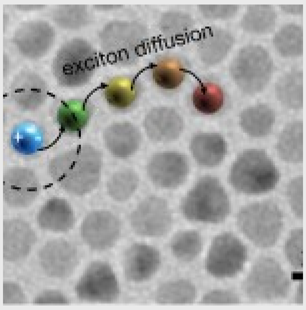
More information on IFIMAC Website

Photonics of Excitonic Nanomaterials: Understanding and Controlling the Flow of Energy



Title: Photonics of Excitonic Nanomaterials: Understanding and Controlling the Flow of Energy
When: Tuesday, 15 March (2016), 12:00h
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Module 3, Seminar Room (5th Floor).
Speaker: Ferry Prins, Swiss Federal Institute of Technology, ETH Zürich, Zürich, Switzerland.

The excited state properties of nanoscale semiconductors are dominated by the dynamics of quantum confined electron-hole pairs known as excitons. Thanks to recent advances in the size and shape control of semiconductor nanomaterials, this confinement can now be tuned with high precision which has resulted in a rapidly expanding family of high-quality excitonic building blocks. However, while extensive research has been done to understand and control the excitonic properties of the isolated building blocks, comparatively little is known about exciton dynamics in nanoscale assemblies.

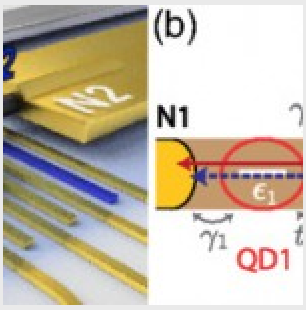
In the first part of the talk, I will present some of our recent efforts in trying to understand and control the exciton dynamics in nanomaterial assemblies. Specifically, I will discuss a new transient microscopy technique with which we can spatially resolve exciton diffusion in colloidal quantum-dot films. In addition, I will present our findings of anomalous excitonic energy-transfer dynamics between zero-dimensional colloidal quantum-dots and two-dimensional MoS2 monolayers.

In the second part of the talk, I will present new strategies for the assembly of excitonic building blocks into high quality wavelength-scale patterns using template stripping of colloidal quantum dot films. I will show that this technique can produce high-quality quantum-dot based grating structures that can significantly modify the optical properties of these films, yielding enhanced and highly directional outcoupling of fluorescence as well as reduced lasing thresholds.

More information on IFIMAC Website

Quantum Interference in a Cooper Pair Splitter Makes Entanglement Production Plausible

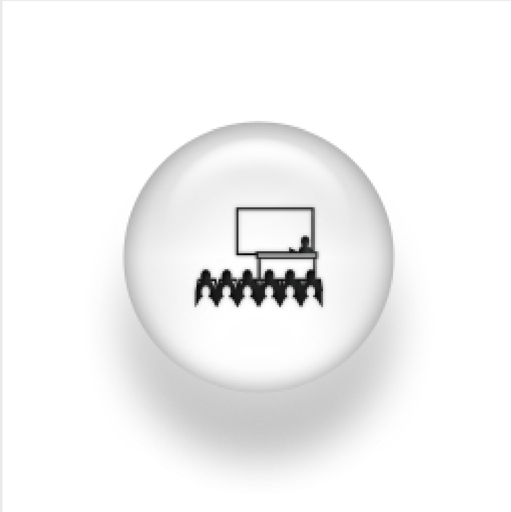
Article: published in Physical Review Letters by Fernando Domínguez and Alfredo Levy Yeyati, Department of Theoretical Condensed Matter Physics and IFIMAC researchers.



In superconductors the electrons occur only in pairs, the so-called Cooper pairs. The electrons in these pairs are (spin) entangled, a quantum mechanical property that is at the heart of any prospective technology that exploits quantum mechanical effects. It was shown recently that these electrons can be separated into two parallel small islands, so-called quantum dots, through which only single electrons can pass at a time. This process is generally known as Cooper pair splitting. But are these electrons potentially useful? Or are the quantum correlations lost already on the dots due to decoherence? Before the experiments and theoretical modeling by Fülöp et al., this question could be answered only by hand-waving arguments and it was not clear for what transport features one should look out. In the present article Fülöp et al. come one step closer to answering these questions: the authors demonstrate interference effects in a Cooper pair splitting device, a clear indication of (spatial) coherence. The use of Niobium as the superconductor allows the authors to tune electron levels not accessible for ordinary electrical gates, and to explain their data they introduce a conceptually new model of such a device. These results are relevant from a fundamental point of view, but also demonstrate the first Cooper pair splitting experiments at large magnetic fields. [Full article]

Spin Coherent Phenomena in Quantum Dots Driven by AC Magnetic Fields

Wednesday, 1 Diciembre 2010. 12:00-13.00



Prof. Gloria Platero
Instituto de Ciencia de Materiales de Madrid, CSIC

ABSTRACT:
Electronic transport through quantum dots can become correlated not only by charge interaction but also by the spin degree of freedom. A combination of both can be found in systems where Coulomb interaction limits their population to a small number of electrons (Coulomb blockade) and where Pauli exclusion principle avoids certain internal transitions – spin blockade. Recent experiments have taken advantage of spin blockade in double quantum dots to achieve qubit operations by means of electron spin resonance (ESR), where an oscillating magnetic field is applied to the sample in order to rotate the electron spin [1]. In ESR experiments, an important issue is to individually address the electron spin in each dot. To this end, it has been proposed to tune the Zeeman splitting of each dot. It can be achieved in systems with different g factor quantum dots [2] or by applying different dc magnetic fields to each dot [3].
In this talk, we analyze coherent spin phenomena in double and triple quantum dots under crossed dc and ac magnetic fields, coupled to normal leads.
In triple dots, in a closed -loop configuration, we discuss the interplay between Aharonov-Bohm current oscillations, coherent electron trapping and spin blockade under two-electron spin resonance configurations [4]. We will also demonstrate for both double and triple quantum dots an unexpected behavior: spin blockade can be not only removed but also induced by tuning the ac field frequency.
We will show as well that in double dots with different Zeeman splittings, strongly spinpolarized current can be achieved by tuning the relative energies of their Zeeman-split levels, by means of electric gate voltages: depending on the energy-level detuning, the double quantum dot works either as spin-up or spin-down filter. In a triple dot, in addition, spin-polarized incoming current can be achieved, and thus the spin-polarizing mechanism can be extended to a spin inversion mechanism [5].

[1] F.H.L. Koppens et al., Nature 442, 766 (2006).
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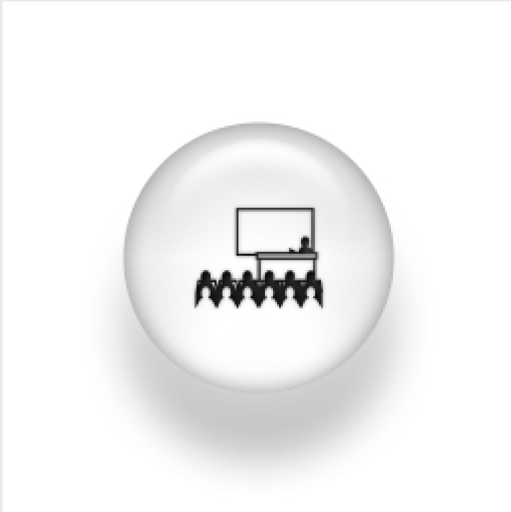
Microcavity-Mediated coupling of two distant semiconductor quantum dots

Wednesday, 27 October 2010, 12:00-13.00



Prof. Pepe Calleja
Departamento de Física de Materiales, UAM

ABSTRACT:
Coupling of semiconductor quantum dot (QD) excitons to the electromagnetic modes of a photonic crystal microcavity is observed. Simultaneous coupling of two distant (1,4 micrometers) quantum dots to the cavity is demonstrated by Purcell effect measurements. Resonant optical excitation of the p state of any of the quantum dots, results in an increase in the s-state emission of the other one. The cavity-mediated coupling can be controlled by varying the excitation intensity. Besides, continuous control of the linear polarization angle of the emitted light is achieved by varying the QD-cavity energy detuning.These results are experimental steps towards the realization of quantum logic operations using distant solid-state qubits and single photon emitters with controlled polarization.

References:
E. Gallardo et al. Optics Express, 18, 13301 (2010).
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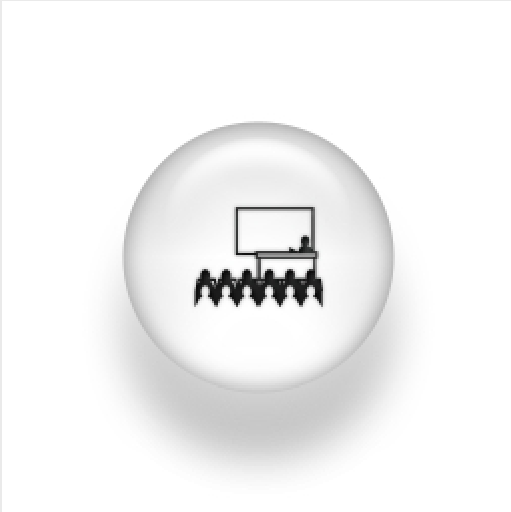
Superconducting molecular quantum dots

Wednesday, 5 May 2010, 12:00-13.00

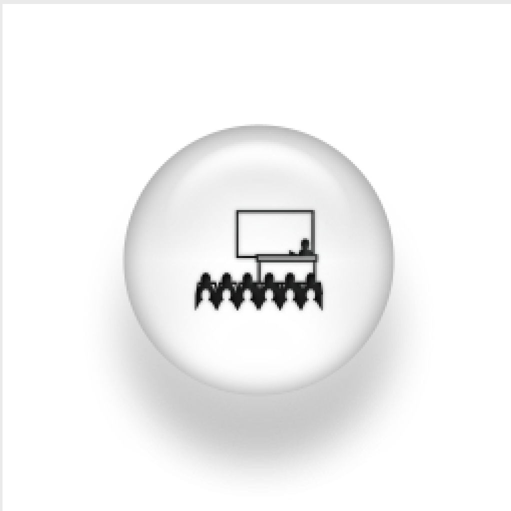


Prof. Reinhold Egger
Universidad de Duesseldorf, Alemania

ABSTRACT:
The Josephson current through nanoscale quantum dots will be discussed in this talk, mainly from a theory point of view. The effects of electron-electron interactions, in particular the interplay of Kondo physics and superconductivity in spin-degenerate quantum dots and in carbon nanotube dots (where a larger SU(4) symmetry can be realized) are addressed. In systems with an internal degree of freedom, it is possible to modify this mode in a dissipationless manner through changes in the superconducting phase difference. This is shown for the case of a two-level system as model of a conformational degree of freedom. I will also discuss effects of spin-orbit coupling, which can induce a spontaneous breaking of time reversal symmetry, leading to an anomalous Josephson current.

Adiabatic pumping through quantum dots

Monday, 17 September 2007, 12:00-13.00



Janine Splettstoesser

Departement de Physique Theorique, Universite de Geneve
A finite charge can be pumped through a mesoscopic system in the absence of an applied bias voltage by changing periodically in time some parameters of the system. If these parameters change slowly with respect to all internal time scales of the system, pumping is adiabatic.
The scope of this work is to investigate adiabatic pumping through a quantum dot, in particular the influence of Coulomb interaction between electrons in the dot on the pumped charge.
On one hand we develop a formalism based on Green’s functions, in order to calculate the pumped charge from the weak-tunnel-coupling regime down to the Kondo regime. We extend our calculations to a system with a superconducting contact.
On the other hand we use a systematic perturbation expansion for the calculation of the pumped charge, giving us the possibility to analyze processes which contribute to charge pumping and to highlight the important role of interaction-induced level renormalization.