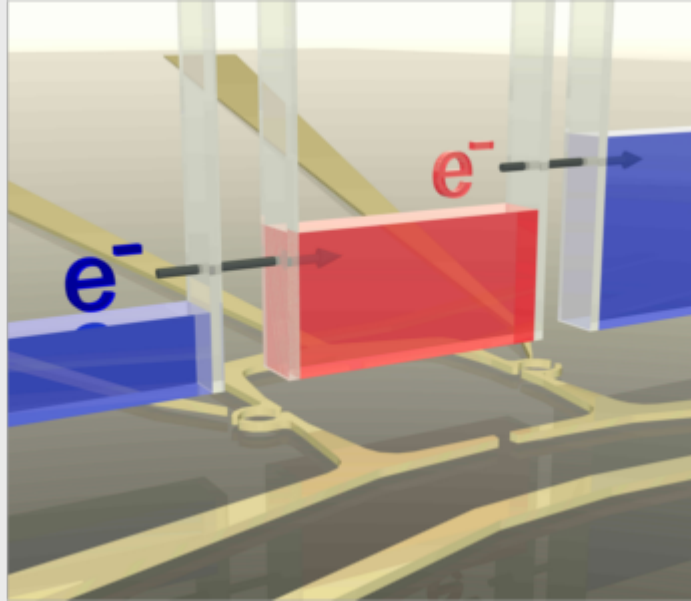


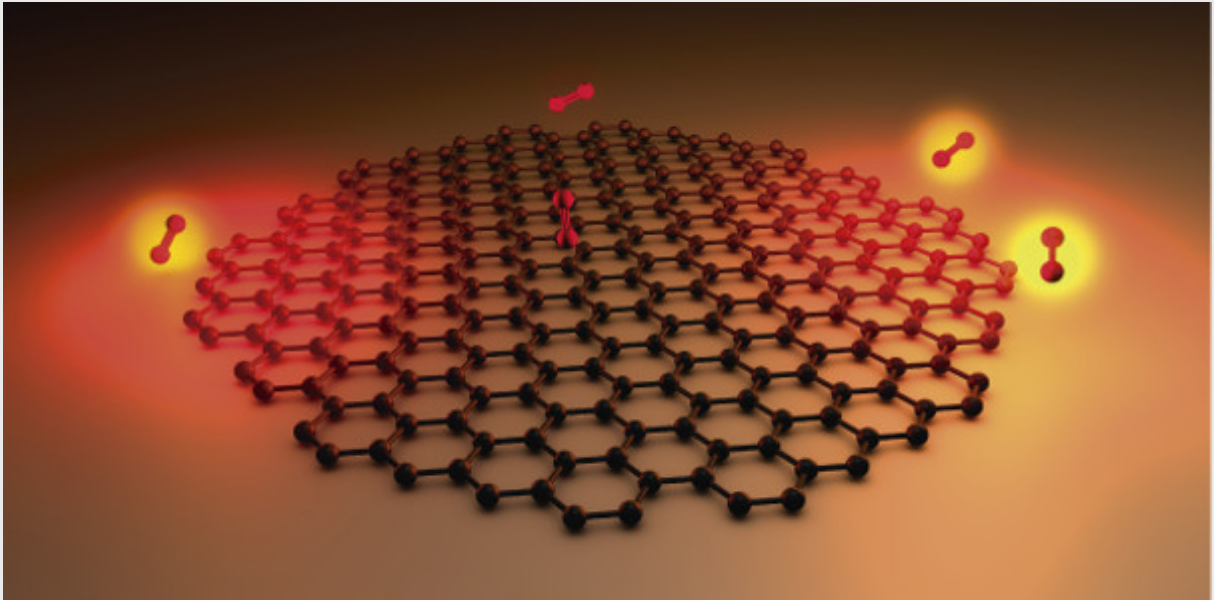
Experimental Realization of a Quantum Dot Energy Harvester



Article: published in [Physical Review Letters](#) by [Rafael Sánchez](#), IFIMAC researcher and member of Department of Theoretical Condensed Matter Physics.

We demonstrate experimentally an autonomous nanoscale energy harvester that utilizes the physics of resonant tunneling quantum dots. Gate-defined quantum dots on GaAs/AlGaAs high-electron-mobility transistors are placed on either side of a hot-electron reservoir. The discrete energy levels of the quantum dots are tuned to be aligned with low energy electrons on one side and high energy electrons on the other side of the hot reservoir. The quantum dots thus act as energy filters and allow for the conversion of heat from the cavity into electrical power. Our energy harvester, measured at an estimated base temperature of 75 mK in a He3/He4 dilution refrigerator, can generate a thermal power of 0.13 fW for a temperature difference across each dot of about 67 mK. [[Full article](#)]

[Metallic Nanostructures and Quantum Emitters](#)



Title: Metallic Nanostructures and Quantum Emitters.

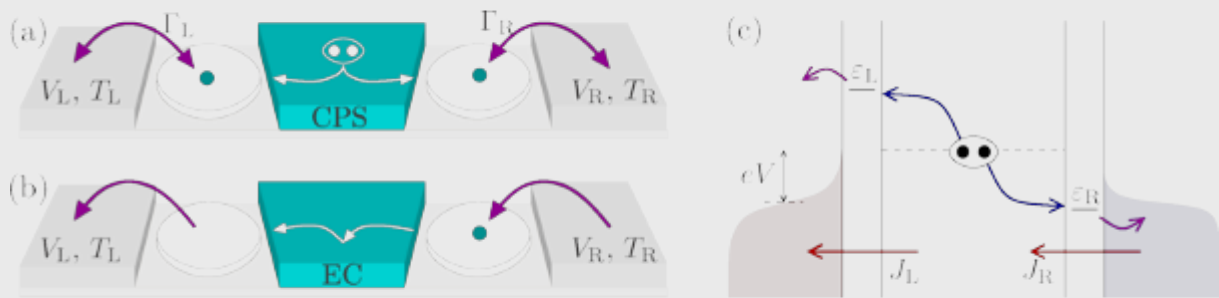
When: Wednesday, April 03, (2019), 12:00.

Place: Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th Floor).

Speaker: Alejandro Manjavacas, University of New Mexico, USA.

The optical response of quantum emitters, such as atoms, molecules, or quantum dots, is strongly modified by their interaction with the near-field of metallic nanostructures that support plasmon resonances. In this talk, we will discuss recent results showing how different metallic nanostructures, ranging from 3D gold elements to 2D graphene systems, can enhance the rates of dipole-forbidden transitions. Furthermore, we will analyze the fundamental limits of the local density of photonic states, a magnitude that quantifies the interaction of a quantum emitter with the local electromagnetic field, through the study of a sum rule that establishes an upper bound to this quantity. Finally, if time permits, we will discuss the response of arrays with multi-particle unit cells using an analytical approach based on plasmon hybridization, which provides a simple and efficient way to design structures with engineered properties.

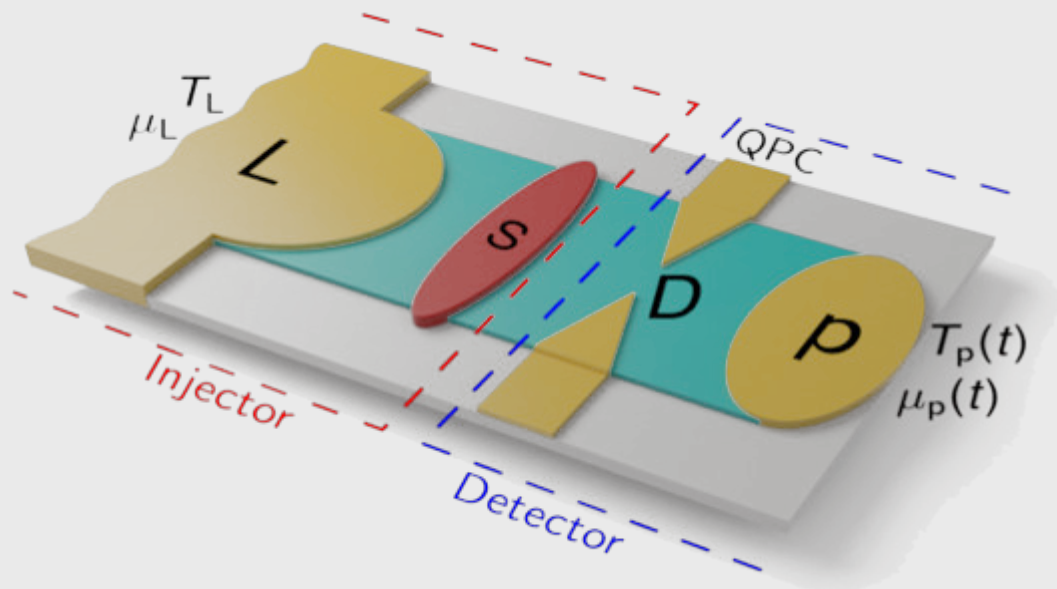
[Cooling By Cooper Pair Splitting](#)



Article: published in [Physical Review B](#) selected as an “Editor’s Suggestion” paper by [Rafael Sánchez](#) and [Alfredo Levy Yeyati](#), [IFIMAC](#) researchers and members of the Department of Theoretical Condensed Matter Physics.

The electrons forming a Cooper pair in a superconductor can be spatially separated preserving their spin entanglement by means of quantum dots coupled to both the superconductor and independent normal leads. We investigate the thermoelectric properties of such a Cooper pair splitter and demonstrate that cooling of a reservoir is an indication of nonlocal correlations induced by the entangled electron pairs. Moreover, we show that the device can be operated as a nonlocal thermoelectric heat engine. Both as a refrigerator and as a heat engine, the Cooper pair splitter reaches efficiencies close to the thermodynamic bounds. As such, our work introduces an experimentally accessible heat engine and a refrigerator driven by entangled electron pairs in which the role of quantum correlations can be tested. [[Full article](#)]

[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.

T

he 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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- N. Dashti, M. Misiorny, P. Samuelsson, and J. Splettstoesser, in preparation.
- N. Dashti, M. Misiorny, P. Samuelsson, and J. Splettstoesser, in preparation.

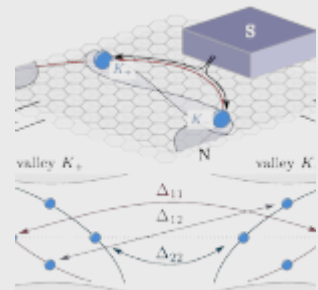
Transport Through Topological Confined States of Matter

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 2π to 4π 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](#)

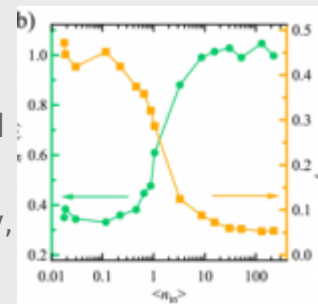
A Single-photon Fock State Filter in the Solid State

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

D. Valente, et al, PRA 86, 022333 (2012).

D. Englund, et al., PRL 108, 093604 (2012); R. Bose, et al., PRL 108, 227402 (2012).

V. Giesz, et al., Nat. Comm. doi:10.1038/ncomms11986.

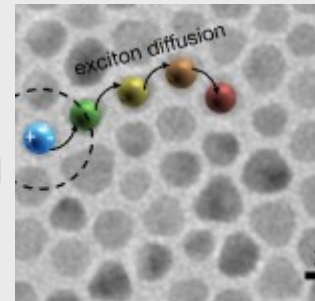
Photonics of Excitonic Nanomaterials: Understanding and Controlling the Flow of Energy

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 de Ciencias, Module 3, Seminar Room (5th Floor).

Speaker: Ferry Prins, Swiss Federal Institute of Technology, ETH Zürich, Zürich, Switzerland.



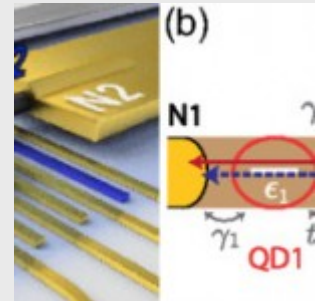
The excited state properties of nanoscale semiconductors are dominated by the dynamics of quantum confined electron-hole pairs known as excitons. Thanks to recent advances in the size and shape control of semiconductor nanomaterials, this confinement can now be tuned with high precision which has resulted 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.

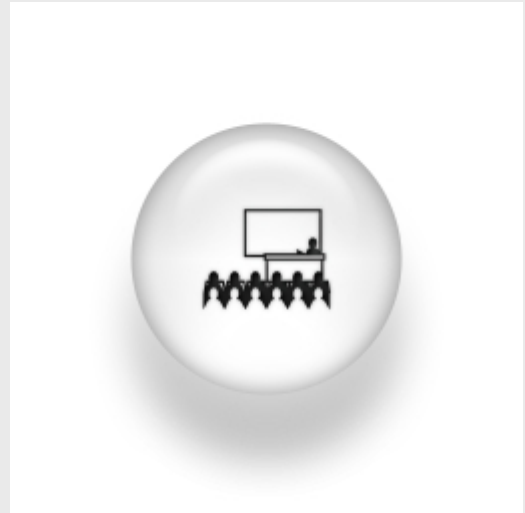
Quantum Interference in a Cooper Pair Splitter Makes Entanglement Production Plausible

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](#)



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].

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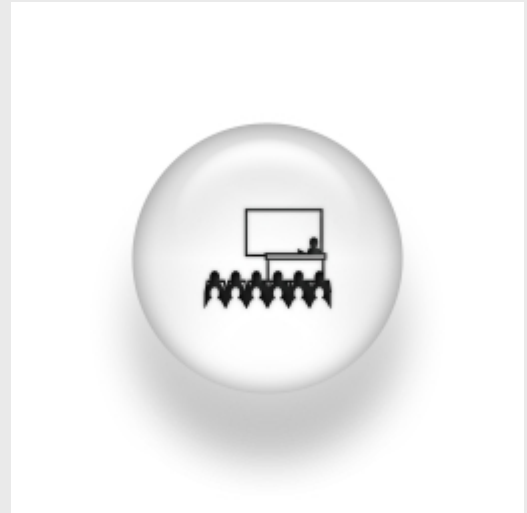
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Microcavity-Mediated coupling of two distant semiconductor quantum dots

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:

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