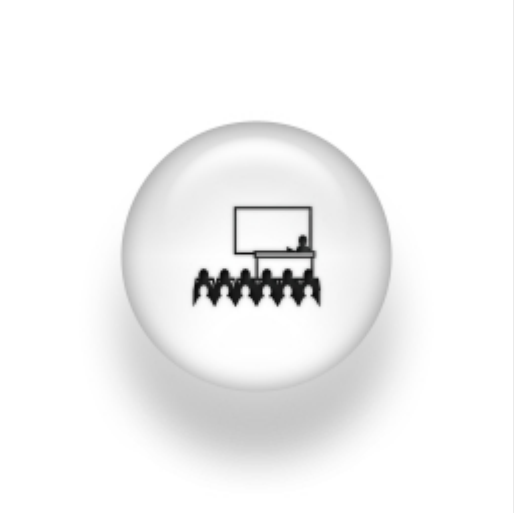
Superconducting molecular quantum dots

Wednesday, 5 May 2010, 12:00-13.00

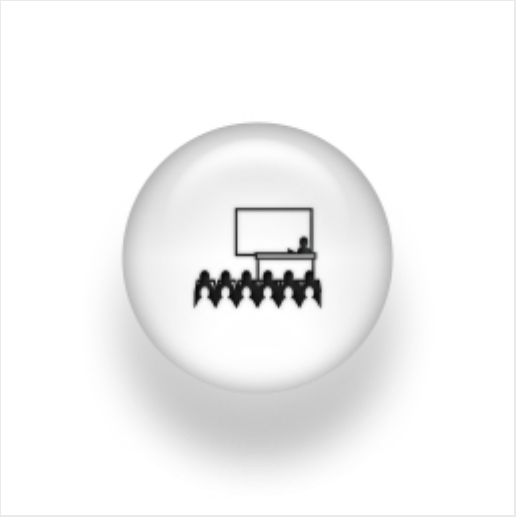


Prof. Reinhold Egger
Universidad de Duesseldorf, Alemania

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.

Spectroscopy of the Andreev Bound States in a Carbon Nanotube

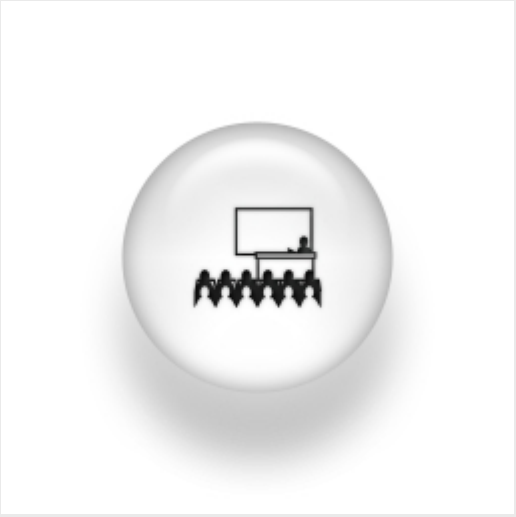
Wednesday, 21 April 2010, 11:30-12.30



Prof. Jean-Damien Pillet
Quantronics Group
CEA-Saclay
ABSTRACT:
Carbon Nanotubes are not intrinsically superconducting, but when they are connected to superconducting leads they can carry a supercurrent. This supercurrent is carried by the Andreev Bound States (ABS) which provide a universal description of the Josephson effect in coherent quantum nanostructures (molecules, nanowires, normal or magnetic layer…) connected to superconductors. We have performed the first tunnel spectroscopy of individually resolved ABS in a nanotube-superconductor device. We analyze the spectrum using a double quantum dot model which reveals notably the spin structure of these levels. Furthermore this device constitutes a new type of SQUID magnetometer.

Persistent currents and quantised vortices in a matter-light superfluid

Wednesday, 7 April 2010, 12:00-13.00

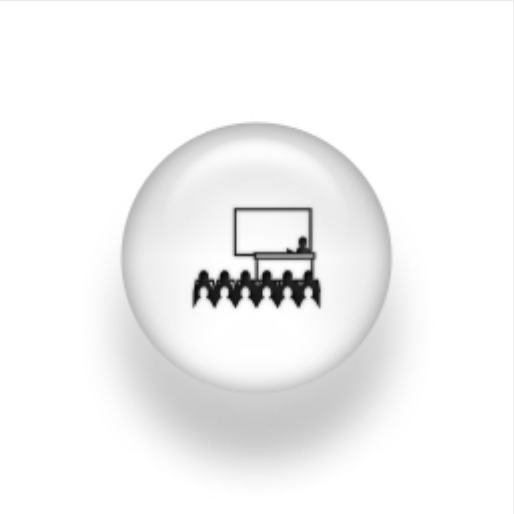


Prof. F. M. Marchetti

Departamento de Fisica Teorica de la Materia Condensada, UAM
ABSTRACT:
Bose-Einstein condensation and superfluidity has been recently revealed in semiconductor microcavities [1,2], inaugurating a new era in the study of strongly coupled light-matter systems. The intrinsic non-equilibrium component enriches the features of such a system and at the same time poses fundamental questions about the properties of a superfluid in a dissipative environment. For example, differently from an equilibrium superfluid, characterised by a flowless ground state, pump and decay in microcavities causes supercurrents even in the steady state regime. I will consider the case of resonantly driven polariton microcavities in the optical parametric oscillator (OPO) regime and report the first observation of a metastable persistent superflow carrying quantum of orbital angular momentum~[3]. The non-equilibrium superfluid can hold a metastable vortex state generated with an external laser and the polariton circulating superfluid persists in absence of the driving rotating probe. The experimental results are compared to, and explained by, a theoretical analysis~[3,4] obtained describing the parametric scattering regime of polaritons via a two-component Gross-Pitaevskii equation, including pump and decay processes. In addition to metastable vortex solutions, which can only be triggered externally, I will show the possibility for stable vortex solutions, where the OPO system undergoes spontaneous symmetry breaking and is unstable towards vortex formation without any driving rotation. To conclude, I will analyse the stability of doubly charged vortices.
[1] J. Kasprzak et al., Nature 443, 409 (2006); R. Balili et al., Science 316, 1007 (2007).
[2] A. Amo, D. Sanvitto et al., Nature 457, 291 (2009); A. Amo et
al. Nature Phys. 5, 805 (2009).
[3] D. Sanvitto, F. M. Marchetti et al., Nature Phys. to appear (preprint arxiv:0907.2371).
[4] F. M. Marchetti et al., preprint arxiv:1003.5111.

Noise Correlations and Coherent Coupling in Solid State Qubits

Wednesday, 24 March 2010, 12:0013.00

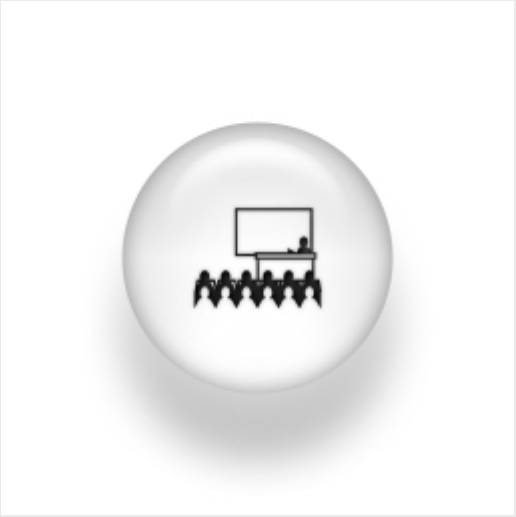


Prof. David Marcos
Instituto de Ciencia de Materiales de Madrid (ICMM)
ABSTRACT:
In this seminar I will present recent advances in the fields of quantum transport and and hybrid quantum systems. The former has incorporated a theory of counting statistics to investigate high-order current correlations through nanoscopic conductors. These can reveal valuable information such as coherence times and phase transitions.
In particular, I will apply the theory to investigate the fluctuation- dissipation theorem in situations out of equilibrium and also show how a non-Markovian description becomes essential to study quantum noise. In the second part, I will review some proposals that combine solid- state and quantum-optics systems in the context of quantum information processing. I shall present a hybrid system consisting on a flux qubit coupled to an ensemble of NV centers in diamond. At high densities coherent transfer between both systems becomes possible, and therefore this opens the possibility of interfacing superconducting qubits with light.

QM/MM Methods: Towards an Efficient and Accurate Description of Biological Photoreceptors and their Rractivity: Rhodopsin-Like Systems as an Example

Wednesday, 24 February 2010, 16:15-17.15

Dr. Pedro B. Coto



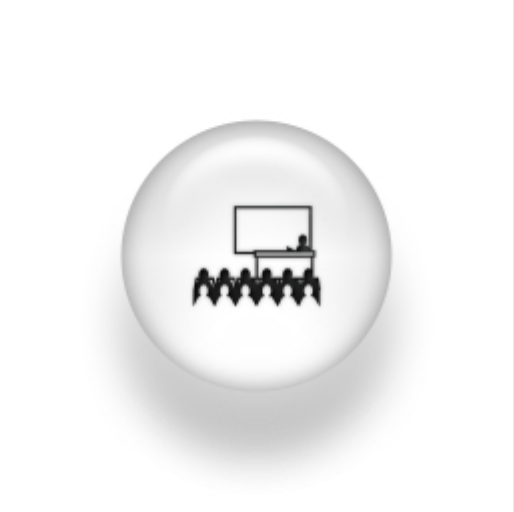
Interdisziplinäres Zentrum für Molekulare Materialien (ICMM)
Friedrich-Alexander-Universität Erlangen-Nürnberg

ABSTRACT:
The description of biological processes induced by light absorption is a challenge for state of the art electronic structure methods. Not only the size of the systems but also the need for an appropriate treatment of different electronic excited states make of the theoretical description of these systems a complex task. In this talk, some of the photo-physicochemical processes carried out by prototypical photoreceptors are characterized by using the QM/MM [1] CASPT2//CASSCF/Forcefield protocol, which is able to offer a balanced description of the different electronic states involved in the reaction by including both static and dynamic correlation effects. In particular, the different factors controlling the wavelength of absorption [2-3] and the molecular mechanism underlying the chemical process [4] are analyzed.

1) A. Warshel and M. Levitt J. Mol. Biol., 103, 227 (1976).
2) P. B. Coto, A. Strambi, N. Ferré, and M. Olivucci, Proc. Natl. Acad. Sci. (USA), 103, 17154 (2006).
3) P. B. Coto, S. Martí, M. Oliva, M. Olivucci, M. Merchán, and J. Andrés, J. Phys. Chem. B, 112, 7153 (2008).
4) A. Strambi, P. B. Coto, L. M. Frutos, N. Ferré, and M. Olivucci, J. Am. Chem. Soc., 130, 3382 (2008).

Quantum control of spin qubits in Silicon

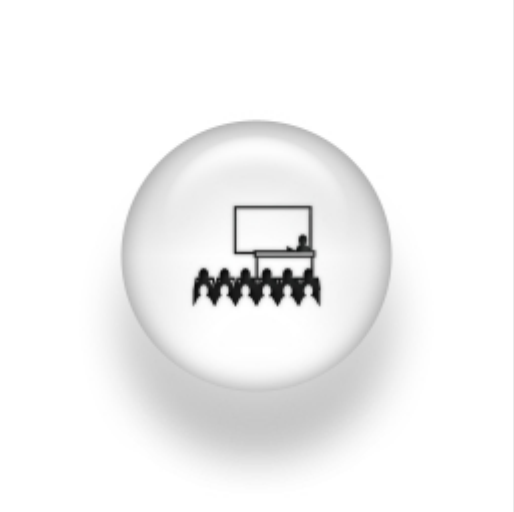
Wednesday, 27 January 2010, 12:00-13.00



Dr. Maria Jose Calderon
Department of theory and simulation of materials.
Instituto de Ciencia de Materiales de Madrid (CSIC)
ABSTRACT:
Doped Si is a promising candidate for quantum computing [1] due to its scalability properties, long spin coherence times, and the astonishing progress on Si technology and miniaturization in the last few decades.
This proposal for a quantum computer ultimately relies on the quantum control of electrons bound to donors near a Si/barrier (e.g. SiO2) interface. I will address several important issues and define critical parameters that establish the conditions that allow the manipulation of donor electrons in Si by means of external electric and magnetic fields [2-4]. In particular, I will discuss the effect of the conduction band degeneracy in Si on this manipulation [3] and how this degeneracy may be lifted at an interface with an insulator [5].
[1] B. Kane, Nature 393, 133 (1998)
[2] M.J. Calderón, B. Koiller, X. Hu and S. Das Sarma, Phys. Rev. Lett. 96, 096802 (2006).
[3] M.J. Calderón, B. Koiller, and S. Das Sarma, Phys. Rev. B 77, 155302 (2008).
[4] M.J. Calderón, A. Saraiva, B. Koiller and S. Das Sarma, Journal of Applied Physics 105, 122410 (2009) [5] A.L. Saraiva, M.J. Calderón, X. Hu, S. Das Sarma, and B. Koiller, Phys. Rev. B 80, 081305 (2009).

Charge and spin transfer statistics of quantum impurity models

Tuesday, 15 July 2009, 12:00-13.00

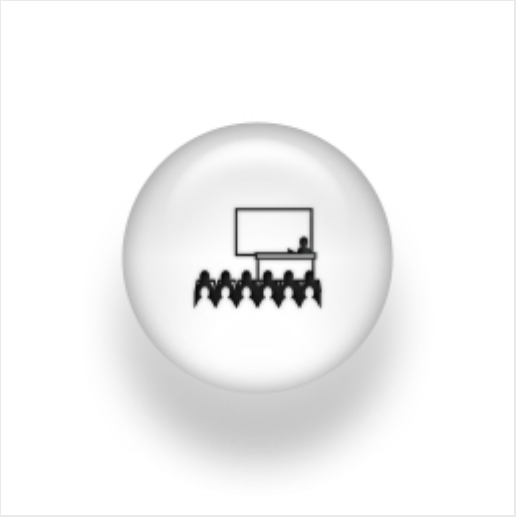


Dr. Andreas Komnik
Institut für Theoretische Physik, Universität Heidelberg
ABSTRACT:
We analyze the full counting statistics (FCS) of the charge and spin transport through the Anderson impurity model (AIM) and similar systems with a single conducting channel. The object of principal interest is the generating function for the cumulants of charge current distribution. We derive an exact analytic formula relating the FCS generating function to the self energy of the system in the presence of the measuring field. We first check that our approach reproduces correctly known results in simple limits, such as the FCS of the resonant level system (AIM without Coulomb interaction) then proceed to study the FCS for the AIM both perturbatively in the Coulomb interaction and in the Kondo regime at the Toulouse point as well as around the its fixed point. At zero temperature the FCS turns out to be binomial for small voltages. For the generic case of arbitrary energy scales the FCS is shown to be captured very well by generalizations of the Levitov-Lesovik type formula. Surprisingly, the FCS for the AIM indicates a presence of coherent electron pair tunnelling in addition to conventional single-particle processes. By means of perturbative expansions around the Toulouse point we succeeded in showing the universality of the binomial FCS at zero temperature in linear response. Based on our general formula for the FCS we then argue for a more general binomial theorem stating that the linear response zero-temperature FCS for any interacting single-channel setup is always binomial.

Modifications of geometric and electronic properties of surface systems caused by structural defects

Monday, 13 July 2009, 12:00-13.00

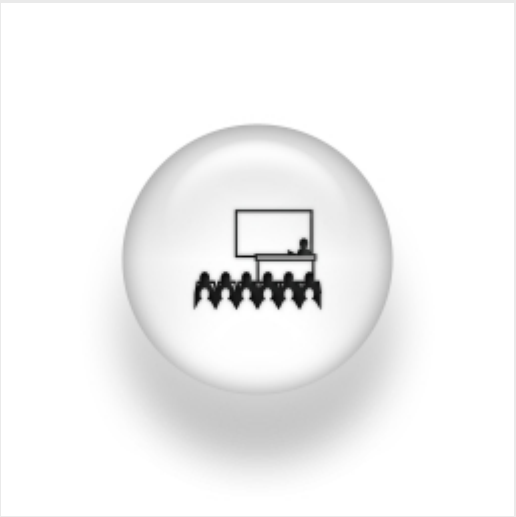
Dr. Barbara Pieczyrak
Department of Physics, University of Wraclaw



Light-matter coupling in photonic crystal structures: from sea-mouse to exciton-polaritons

Tuesday, 12 May 2009, 12:00-13.00

Dr. Creatore Celestino

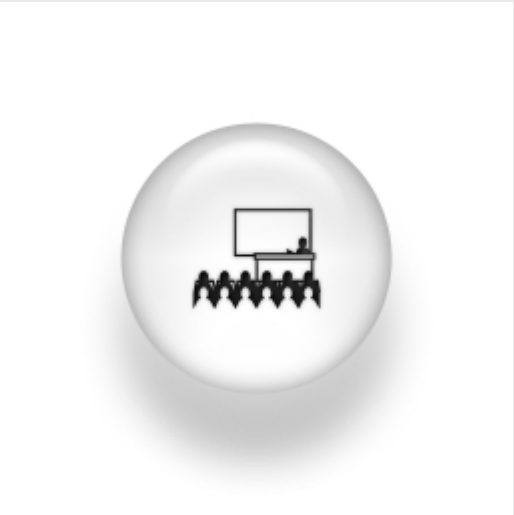


Universitá degli Studi di Pavia, Italy
ABSTRACT:
Photonic crystals (PhCs), structures characterized by a spatially periodic dielectric function, are nowadays very appealing due to their rich physics. In particular, the occurrence of photonic band gaps, i.e. frequency regions where propagation of light is strongly inhibited, and the ability to manipulate and control the photonic flow of light, make PhCs interesting for many applications. Furthermore, the present accurate engineering of photonic states allows to investigate light-matter coupling in PhCs in both weak and strong coupling regimes. For the former limit, we examine the

modifications of the spontaneous emission from a dipole embedded in a generic one-dimensional (1D) photonic structure, and we show a model derived within a quantum-electrodynamical formalism, discussing its extension to two-dimensional PhCs (like Photonic Crystal slabs). For the strong-coupling regime, we analyze some interesting features of Bragg-polaritons, i.e. the extra intragap modes resulting from the strong coupling between Bragg photon modes in a 1D Bragg mirror and bulk excitons.

The effect of the supporting oxide on the activity of vanadia catalysts

Monday, 11 May 2009, 15:00-16.00



Dr. M.V. Ganduglia-Pirovano
Institute of Chemistry, Humboldt University, Berlin (Germany)
ABSTRACT:
As the pressure and materials gaps between real catalysis and traditional UHV single crystals studies are narrowing, experiments and modelling that straddle both sides of the gap appear essential to understand surface properties and functions of catalysts. The strong influence of the oxide support on the catalytic activity of vanadium oxides (VOx) in oxidation reactions is well-known, yet not understood. Here, I will report theoretical models of VOx/Al2O3 as well as of VOx/CeO2(111). These case studies were investigated using density functional theory-based calculations and statistical thermodynamics. I will show that the results obtained for the computational models for VOx/support systems are consistent with the experimental knowledge for powder catalysts and experimental model catalysts and thus help to bridge the gap between them.
The high catalytic activity of vanadia supported on ceria as compared to alumina is discussed on the basis of the relative ease of reduction of vanadia, ceria and alumina. If time permits, I will discuss the self-assembly of nanosized Au chains on an ultrathin alumina film; a model system of another class of oxidation catalysts, namely, oxide supported (noble) metal particles.