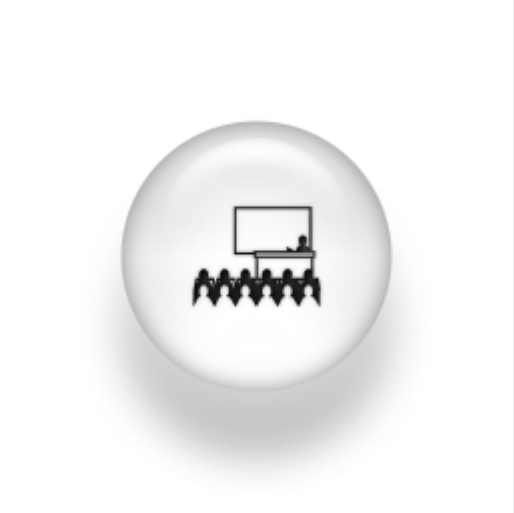
Probing the spin of a single atom with tunneling electrons

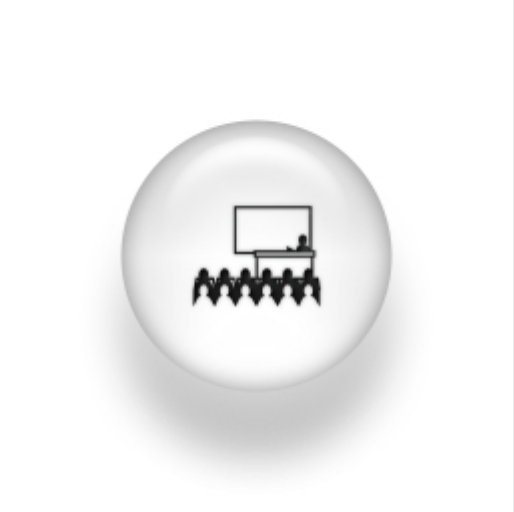
Wednesday, 15 April 2009, 12:00-13.00



Dr. Joaquín Fernández-Rossier
Universidad de Alicante
ABSTRACT:
Recent [1-3] work shows that inelastic electron scanning tunneling microscope (STM) probes the elementary spin excitations of a single and a few magnetic atoms in a thin insulating layer. In this talk I discuss how this new type of spectroscopy can be modeled using a phenomenological spin-assisted tunneling Hamiltonian [4]. Within this formalism, the inelastic dI/dV lineshape is related to the spin spectral weight of the probed magnetic atom. This accounts for the spin selection rules observed experimentally. The theory agrees well with existing STM experiments for single Fe and Mn atoms as well as linear chains a few Mn atoms. The magnetic anisotropy in the inelastic dI/dV and the marked odd-even N effects are accounted for by the theory. I discuss ultimate origin of both the magnetic anisotropy and the spin-assisted tunneling Hamiltonian in terms of a generalized Anderson model in the cotunneling regime and I compare with results for a similar model in the sequential tunneling regime [5].
[1] A. J. Heinrich, J. A. Gupta, C. P. Lutz, D. M. Eigler, Science 306, 466 (2004)
[2] C. F. Hirjibehedin, C. P. Lutz, A: J. Heinrich, Science 312, 1021 (2006)
[3] C. Hirjibehedin, C-Y Lin. A.F. Otte, M. Ternes, C. P. Lutz, B. A. Jones, A. J. Heinrich, Science 317, 1199 (2007)
[4] J. Fernández-Rossier Theory of single spin inelastic tunneling spectroscopy, arXiv: 0901.4839
[5] J. Fernández-Rossier and R. Aguado, Phys. Rev. Lett. 98, 106805 (2007)

Many-body physics in arrays of ultracold atoms

Tuesday, 24 March 2009. 12:00h



Dr. Diego Porras
Universidad Complutense de Madrid
ABSTRACT:
Experimental setups such as trapped ions and ultracold neutral atoms in optical lattices provide us with a toolbox to implement a rich variety of models from condensed matter physics. In this talk I will present our theoretical proposal to use trapped ions to study quantum magnetism and models of interacting bosons, as well as a few experimental results on the implementation of this idea. I will also present some recent theoretical work on matter-wave superradiance of ultracold neutral atoms in optical lattices.

Interplay of Coulomb correlations and geometrical frustration in two-dimensional compounds

Wednesday, 18 March 2009, 15.00-16.00

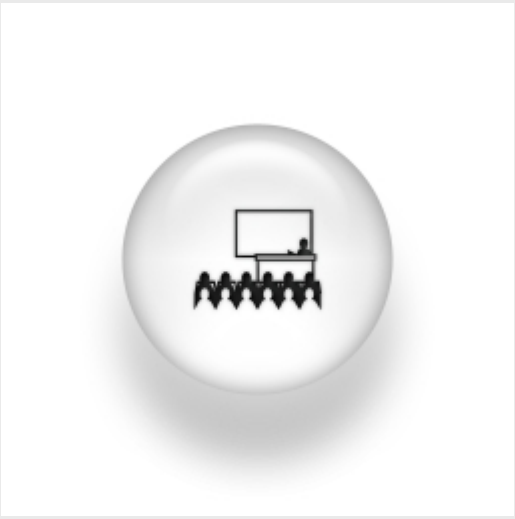
Dr. Jaime Merino

Universidad Autónoma de Madrid
ABSTRACT:
The behavior of strongly interacting electrons in two-dimensions is yet poorly understood. An important challenge is to understand the interplay between local and

spatial correlations induced by the Coulomb interaction which occurs in, for example, layered organic superconductors and cuprates.
These systems can be considered as benchmarks of the bandwidth controlled or doped controlled Mott transitions, respectively.
Since in these materials the Coulomb repulsion energy is comparable to their bandwidth, perturbative or mean-field approaches fail to describe many of their unconventional properties observed.
In the present talk, we show how modern versions of dynamical mean-field theory extended to clusters (CDMFT) can deal with on-site dynamical and spatial correlations on equal footing avoiding uncontrolled approximations.
As a recent application, we discuss the Hubbard model on an anisotropic triangular lattice, which is the minimal model relevant to the layered organic superconductors. We find that small deviations from the isotropic limit leads to qualitative changes in the temperature-Coulomb interaction phase diagram which are in overall good agreement with observations in various organic materials. A clear correlation between the spin degrees of freedom and the different phase diagrams is discussed.

Intermolecular interaction in DFT : Application to Carbon Nanotubes and Fullerenes

Wednesday, 4 March 2009, 12:00-13.00



Dr. Y.J. Dappe
Institut de Physique et Chimie des Matériaux de Strasbourg
ABSTRACT:
A theoretical study of weak interactions in graphitic materials like Carbon Nanotubes, Fullerenes and graphene is presented here. Based on a localized orbitals DFT formalism, our treatment which has already been applied for graphene-graphene interaction describes independently the weak chemical as well as the van der Waals interaction with high accuracy. The weak chemical interaction is described in the frame of the LCAO-S2 model based on a weak overlap expansion, and the van der Waals interaction

is treated in the dipolar approximation, taking into account virtual transitions of high energy. This formalism is applied here to the case of lateral interaction between CNTs, C60-dimers, adsorption of C60 on graphene and CNT, and encapsulation of C60 and CNT. The power law of the interaction is analyzed, and useful parameters like C60 coefficient and an exponential model for the “chemical” interaction are extracted. Beyond the study of graphitic materials, this work opens new perspectives in the analysis of weakly bounded metal/organics interfaces.

M.A. Basanta, Y.J. Dappe, J. Ortega and F. Flores, Europhysics Letters 70, 355 (2005).
Y.J. Dappe, M.A. Basanta, F. Flores and J. Ortega, Physical Review B 74, 205434 (2006).
Y.J. Dappe, J. Ortega and F. Flores, submitted to Physical Review B (2008).

Control and instability of a periodically-driven Bose-Einstein condensate

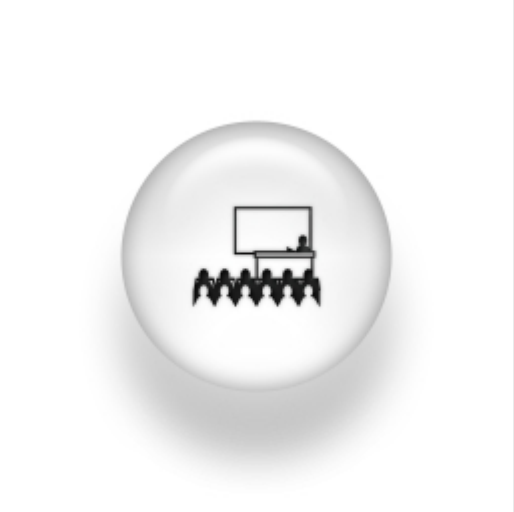
Thursday, 26 February 2009, 15:00-16.00

Dr. Charles Creffield
Universidad Complutense de Madrid

ABSTRACT:
Applying an optical lattice potential to a Bose-Einstein condensate gives the opportunity to study coherent quantum phenomena in extremely clean and controllable conditions. One such effect is termed “coherent destruction of tunneling”, in which periodically shaking the lattice causes the intersite tunneling to be renormalised to an effective value. Using a mean-field approach I will first show how the dynamical stability of the condensate crucially depends upon the sign of the effective tunneling. I will then show how controlling the tunneling can be used to precisely control the localization and entanglement of individual particles, and how this effect can be harnessed to investigate the interplay between nonlinearity and dispersion, notably in the production of solitons.

Three-Dimensional Force Imaging and Quantification with Atomic Resolution

Wednesday, 11 February 2009, 12:00-13.00



Dr. Mehmet Z. Baykara
Departments of Mechanical and Chemical Engineering and Center for Research on Interface Structures and Phenomena. Yale University.

ABSTRACT:
Site-specific chemical interactions at surfaces govern various scientific and technological fields including catalysis, thin film growth, and tribology.
Full control over design processes in these fields requires quantitative, site-specific knowledge of the surface force field with atomic resolution in three dimensions. Until now, such information has only been theoretically accessible. Here we demonstrate a noncontact atomic force microscopy-based approach to experimentally obtain this data and show that it can be used to image the three-dimensional surface force field of graphite, as well as the interaction potential and the dissipation. Graphite has been chosen due to its importance as a solid lubricant as well as a model for sp2-bonded materials. We show normal force maps with picometer and piconewton resolution that allow a detailed characterization of the distance-dependent surface-probe interactions in all directions. Within these maps, the positions of all atoms are identified, and differences between atoms at inequivalent sites are quantified. In addition, dissipation and lateral force characteristics of the surface are analyzed. The results suggest that the origin of graphite’s excellent lubrication properties may lay in a remarkable localization of the lateral forces.

Short Bio:
Mehmet Z. Baykara got his undergraduate degree from the Department of Mechanical Engineering at Bogazici University in Istanbul, Turkey with high honors in 2006. The same year he started his Ph.D. studies at Yale University under the supervision of Prof. Udo Schwarz. Currently he’s in the third year of his studies.

Transport studies of self-assembled InAs quantum dots contacted with superconducting leads

Tuesday, 3 February 2009, 12:00-13.00

Dr. R. S. Deacon

Tarucha laboratory, University of Tokyo, Department of Applied Physics and
QPEC, Bunkyo Ku, 7-3-1 Hongo, Tokyo 1138656, Japan.

ABSTRACT:
Self-assembled InAs quantum dots are a promising system for Quantum information processing, possessing excellent and well studied optical properties and strong spin-orbit coupling. Recently the transport properties of single uncapped InAs quantum dots have been accessed using nanogap electrodes[1,2,3] with a back gate used to control the chemical potential of the dot. I will discuss recent transport measurements on single self assembled InAs quantum dots in our lab with a focus on devices with superconducting leads.
I will discuss recent measurements on devices with normal and superconducting leads in which the spectral properties of the QD are probed through electron tunnelling. At temperatures below the transition temperature of the superconducting lead the low bias current is transmitted through Andreev reflections which require pairing of electrons upon the quantum dot and are therefore extremely sensitive to correlation effects such as Coulomb interaction and the many-body Kondo effect. We identify signature of strong Proximity effect in resonant Andreev conductance and observe that the for appropriate device parameters the Kondo singlet state enhances zero bias Andreev conductance. We also study single InAs self-assembled quantum dots contacted with superconducting Aluminium nanogaps. We select devices with high coupling of leads and dot to observe Josephson supercurrent which reveals interplay between proximity effect and electron-electron interaction.
[1] M. Jung et al., App. Phys. Lett., 86, 33106 (2005).
[2] K. Shibata et al., Appl. Phys. Lett., 91, 112102 (2007).
[3] C. Buizert et al., Phys. Rev. Lett., 99, 136806 (2007).

Unusual elastic and inelastic behaviors of carbon nanotubes due to molecular encapsulations: Dynamic force microscopy and spectroscopy studies

Thursday, 22 January 2009, 12:00-13.00

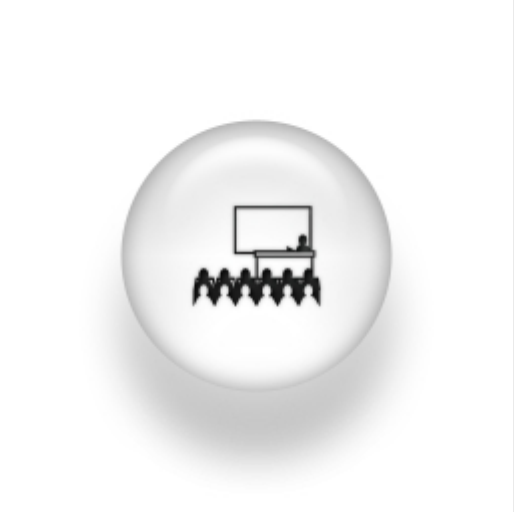
Dr. Makoto Ashino

Institute of Applied Physics and Microstructure Research Center
University of Hamburg.

ABSTRACT:
Atomic force microscopy (AFM) has become versatile and powerful method for imaging both insulating and conducting material surfaces down to the atomic scale. By extending its high spatial resolution and sensitivity to force spectroscopy dimension, mechanical responses of sample materials can be studied with atomic resolution. Using 3D mapping of force and damping fields, we address individual molecules of Dy@C_82 fullerene confined inside carbon nanotubes and control their oscillatory behavior via attractive interactions with the AFM probe tip [1]. Furthermore, we discuss that detailed analysis of individual force vs distance relationships could reveal unusual elastic and inelastic behaviors of carbon nanotubes due to nearly frictionless motions of encapsulated fullerene molecules.

Numerical evaluation of four-center molecular intergals for localized orbitals

Wednesday, 14 January 2009, 15:0-16.00



Dr. Masayuki Toyoda
Japan Advanced Institute of Science and Technology (JAIST) 1-1, Asahidai, Nomi, Ishikawa 923-1292, Japan.
ABSTRACT:
We have developed a computer routine to evaluate the four-center molecular integrals for the pseudo-atomic orbital basis sets.
This enables us to calculate the Fock exchange energy for Kohn-Sham orbitals within order-N DFT calculations.
In our test calculations with simple molecules, the convergence up to 10^-5 Hartree in energy has been successfully achieved at an acceptable computation cost.

Dissipative Systems and Non-Equilibrium Bose-Einstein Condensation: from microcavity polaritons to atom lasers

Wednesday, 17 December 2008, 12:00-13.00

Dr. Marzena Szymanska

University of Warwick
By confining photons in a semiconductor microcavity, and strongly coupling them to electronic excitations, one may create polaritons: bosonic quasi-particles with an

effective mass of 10-9 times that of Rubidium atoms, thus allowing BEC at elevated temperatures. After a long and strenuous search, the comprehensive set of experiments has finally given evidence for BEC of polaritons. However, this new condensate depart from the archetypal BEC in several ways. Most importantly, polaritons have short lifetime and so a continues pumping is required to sustain a steady-state. This leads to a new type of condensation which can exist in highly non-equilibrium and dissipative environment.
I will discuss that, surprisingly, the mechanism of condensation, connected with the chemical potential reaching the bottom of bosonic modes, is the same in closed systems at equilibrium and in open systems with pump and decay.
However, even when the system is characterized by a thermal distribution, the presence of pumping and decay significantly modifies the spectra of phase fluctuations leading to correlation functions — and thus condensate lineshape
– that differ both from an isolated condensate and from that for phase diffusion of a single laser mode. I will also comment how these effects might be relevant for the properties of the atom lasers. These generic features of dissipative condensation can be observed in different optical probes; they also affect the decay of spatial and temporal coherence in a condensate; and modify its superfluid properties.