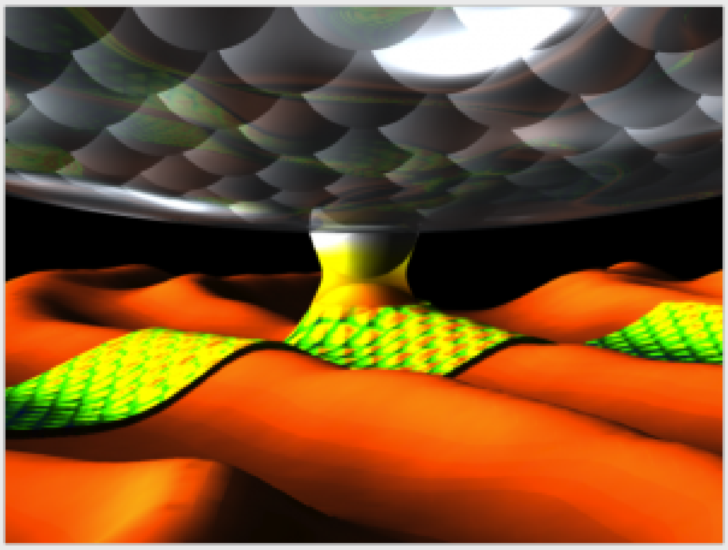
The Small Frontier: Imaging Atomic and Molecular Functionality

Date: Friday, 7th March 2014.



Time: 12:00h
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).
Klaus Kern (Max-Planck-Institute for Solid State Research (MPI-FKF) and Ecole Polytechnique Fédérale de Lausanne – EPFL).

ABSTRACT:

The advent of scanning probe microscopy has provided the unique ability to investigate matter with ultimate precision. Single atoms and molecules can today not only be imaged with unprecedented resolution but also probed by local spectroscopy, manipulated to assemble functional nanostructures and excited to induce chemical change. In the present talk I will present our recent efforts to push the limit of scanning probe microscopy and spectroscopy by exploiting ultralow temperatures (10mK) and high magnetic fields (14T) as well as by developing novel vacuum interfaces for the controlled handling of large molecules with negligible vapor pressure. The experiments provide unprecedented microscopic details of single molecule and atom junctions, quantum magnetism, single molecule electrodynamics and protein folding. Many new perspectives ranging from quantum critical phenomena through molecular engineering to energy conversion are opened up by these developments.

More information on IFIMAC Website

Quantum Merging: A Physical Mechanism for non-Abelian Matter

Date: Friday, 28st February 2014.

Time: 12:00h
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).
Belén Paredes (Instituto de Física Teórica UAM/CSIC).

ABSTRACT:

Topological states of matter represent an exotic organizational form of quantum matter that contradicts the traditional paradigms of condensed matter physics. Our understanding of how topological order emerges from the microscopic degrees of freedom of a quantum many-body system is far from complete. Especially intriguing is the possible formation of non-Abelian topological phases, whose excitations display non-Abelian braiding properties with potential application for quantum computing.

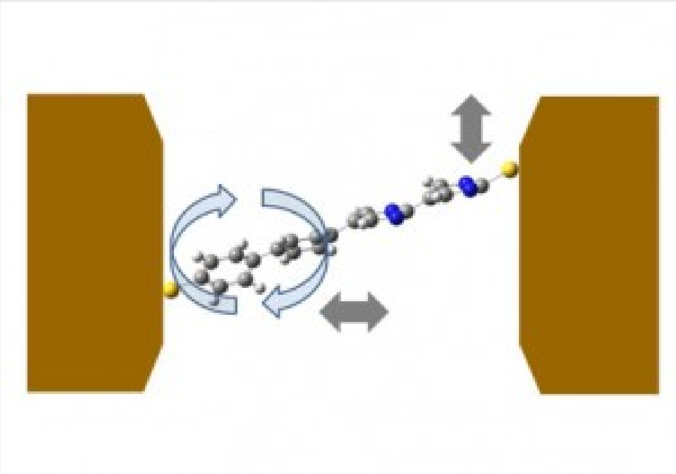
In this talk I will propose a physical mechanism for the emergence of non-Abelian topological phases: the quantum merging of identical copies of the same many-body state. I will argue that such a global organization, in which particles are organized into identical indistinguishable groups, can give rise to topological quasiparticles obeying non-Abelian statistics. To illustrate the construction, I will present a physical realization of this type of order in a spin-1 lattice model. In the ground state, spins are organized in two identical quantum loop condensates. Excitations with non-Abelian braiding properties are created by opening loops in each of the copies. My proposal might open a door for the understanding of the origin of topological states of matter and for the experimental realization of non-Abelian anyons in the laboratory. Nano optics is devoted to understanding the electromagnetic field behavior when probed at length scales smaller than the visible wavelength. This is a vast field of research encompassing from foundational issues to technological applications. The propagation of light and its confinement at small volumes are two of the main aspects researched in our group. The modulation of the optical field at the mentioned scales requires the interaction of light with materials structured at micro- and nanometer dimensions. Such structures include quantum dots, graphene ribbons, microcavities, and metallic waveguides, among others. Given the considered sizes, the analysis has to account both for quantum and

classical phenomena. At the quantum level we investigate, for instance, how the modification of the electromagnetic environment can profoundly affect the emission properties of molecules and artificial atoms. Such modification can be used to control quantum mechanical degrees of freedom of the emitter system, and allows for the manipulation of its entanglement. On the classical side we can mention, as an example of our work, the use of transformation optics techniques to mold the propagation of surface plasmons. we also study metamaterials, a family of systems where function arises as a consequence of periodic structuring at scale smaller than the operating wavelength. Although many of the considered metamaterial systems typically operate at much slower frequencies than those commented above, they can be approached with the same theoretical and computational tools that we use in nano-optics. Metamaterials can lead to entirely novel electromagnetic phenomena not available in nature and find a large number of applications in plasmonics, photonics, acoustics, and many other wave-like phenomena.

More information on IFIMAC Website

Non-equilibrium Transport Theory Compared with Experiments on Single Molecular Junctions

Date: Friday, 21st February 2014.



Time: 12:00h

Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).

Yoshihiro Asai (National Institute for Advanced Industrial Science and Technology (AIST), Tsukuba, Japan).

ABSTRACT:

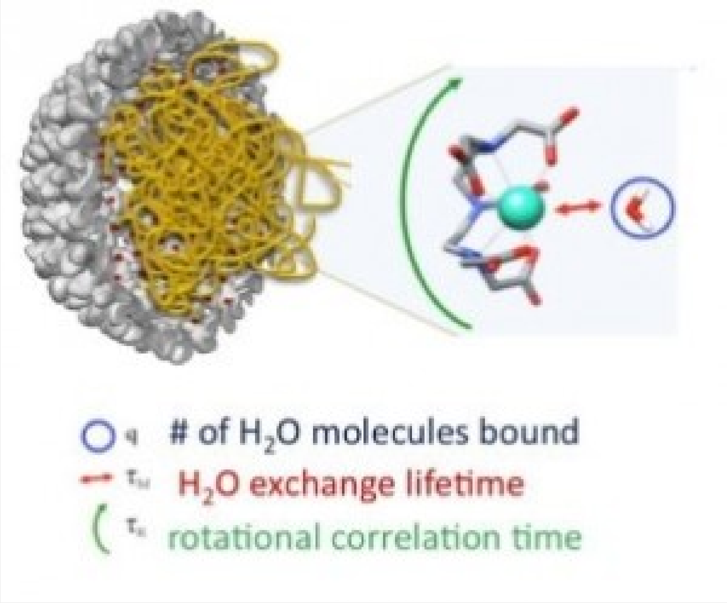
Non-equilibrium quantum transport theory extended to include phonon transport, electron-phonon scattering effect, electron correlation effect, and heat dissipation effect has been successful to describe various experimental findings observed in single molecular junctions and atomic wires. Examples include the local heating effect, material dependence of the inelastic tunneling spectroscopy (IETS) line shape, electron correlation effect in the enhanced of rectification ratio at high bias voltage, temperature and length dependences of the electric conductance and its zero bias anomaly at very low temperature. In this talk, comparisons with the theory and experiments will be focused including physics and chemistry of molecular junctions.

The packaging of material on the inside of the protein cages can dramatically change the physical properties of both the cage and the encapsulated cargo. We are investigating the effects of molecular crowding on encapsulated enzymes and polymers, the effects of the protein cage on the surface properties of encapsulated magnetic materials, and the influence of the encapsulated cargo on the physical properties on these composite materials. We are developing a wide range of bio-inspired composite materials that integrate protein architecture with organic and inorganic synthetic components. In particular, the use of these protein cage nano-materials as targeted therapeutic and diagnostic agents and as controlled nano-reactors will be discussed.

More information on IFIMAC Website

Packing Them In: Using Self-Assembled Protein Cages to Direct the Synthesis and Packaging of Polymers, Minerals, and Proteins

Date: Wednesday, 12th February 2014.



Time: 12:00h

Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).

Trevor Douglas. (Department of Chemistry Indiana University).

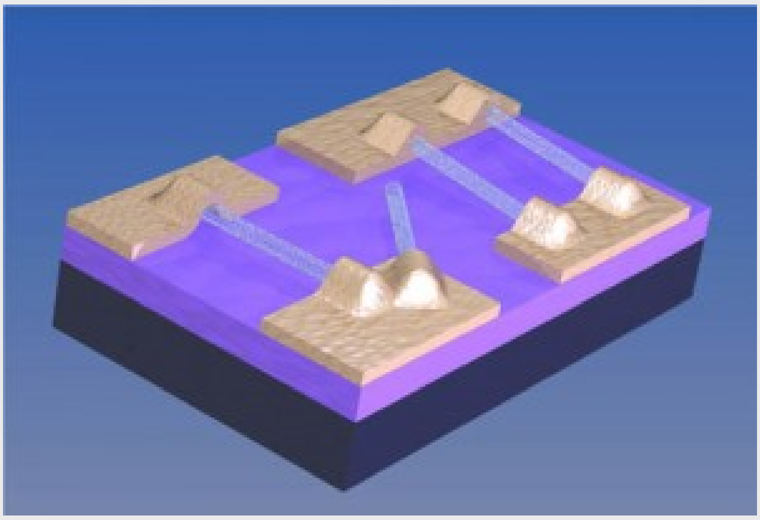
ABSTRACT:

Protein cages have emerged as useful platforms for synthetic manipulation with a range of applications from materials to medicine. Synthetic manipulation can impart new function, combining the best of evolution and directed synthetic design. We have developed a library of protein cage architectures, which differ in size, porosity, and stability, for synthetic manipulation. This library of cages include ferritins (and ferritin-like proteins), virus capsids, and heat shock proteins. Ferritins, derived from hyperthermophiles, are stable to temperatures above 100 ºC and are useful in the synthesis of magnetic and semiconducting nanoparticles. The unique scaffold-templated self-assembly of the bacteriophage P22 capsid has been utilized for the directed synthesis and packaging of a range of gene products as well as organic, and inorganic, polymeric materials. The use of virus capsids has resulted in a paradigm shift from the study of viruses as disease causing agents to their realization as highly useful supramolecular assemblies, which can be chemically and genetically modified.

More information on IFIMAC Website

Superconductor Nanowire Superconductor Junctions as Useful Platforms to Study Topological Superconductivity and Majorana Bound States

Date: Friday, 7th February 2014.



Time: 12:00h

Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).

Ramón Aguado (Instituto de Ciencia de Materiales de Madrid-CSIC).

ABSTRACT:

Recent experiments have reported conductance measurements in semiconducting nanowire-based systems that support the existence of Majorana bound states (MBS) at normal-superconductor (NS) junctions.

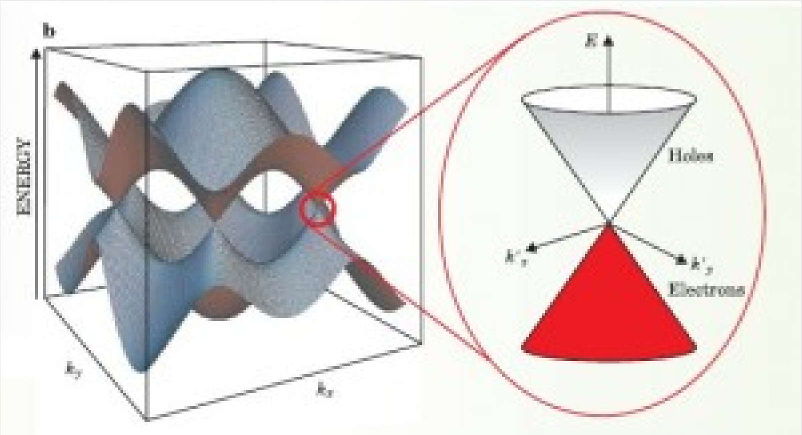
Although these experiments are partially consistent with the Majorana interpretation, other mechanisms such as disorder, Kondo physics, or Andreev bound states cannot be completely ruled out. It has thus become urgent to study alternative “smoking gun” measurement protocols. In this talk, I will argue that SNS junctions based on nanowires are extremely useful platforms to perform such alternative measurements.

Physical quantities that provide relevant information about MBS in such junctions include ac Josephson currents, multiple Andreev reflection (MAR) currents and supercurrents in multiband systems. Remarkably, the emergence and annihilation of MBS in multiband junctions is reflected in strong even-odd effects in the critical current Ic under specific conditions. This effect allows for a full mapping between Ic and the topological phase diagram of the junction.

More information on IFIMAC Website

Strained Graphene Revisited

Date: Friday, 24th January 2014.



Time: 12:00h

Place: Departamento de Física Teórica de la Materia Condensada, Facultad Ciencias, Módulo 5 , Aula de Seminarios (5ª Planta).

María A. H. Vozmediano (Instituto de Ciencia de Materiales de Madrid-CSIC).

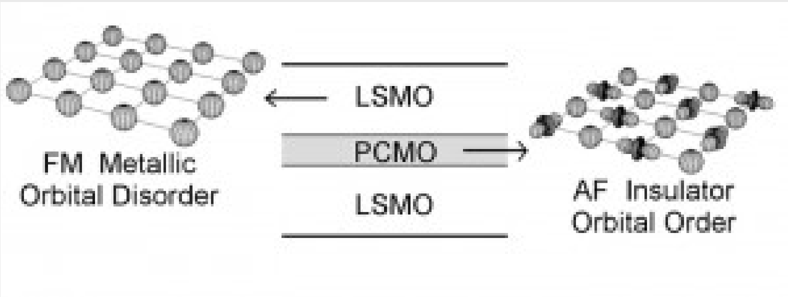
ABSTRACT:

We investigate some apparent discrepancies between two different models for

curved graphene: the one based on tight-binding and elasticity theory, and the covariant approach based on quantum field theory in curved space. We demonstrate that strained or corrugated samples will have a space-dependent Fermi velocity in either approach that can affect the interpretation of local probe experiments in graphene. We also generalize the tight-binding approach to general inhomogeneous strain and find an extra vector field proportional to the derivative of the strain tensor that has the same form as the one obtained in the covariant approach. Finally we show that extra terms arise in the continuum limit of the tight-binding Hamiltonian due to frame effects which cannot be accounted for by changes in the hopping parameters due to lattice deformations, encoded in the parameter.
More information on IFIMAC Website

Anisotropic Magnetoresistance and the Nature of the Electronic Reconstruction in Oxide Heterostructures

Date: Friday, 17th January 2014.



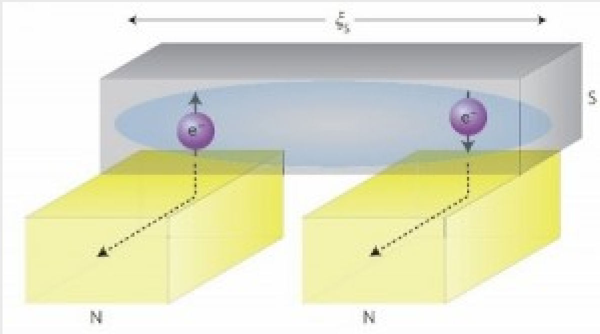
Time: 12:00h
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta).
María José Calderón. (Instituto de Ciencia de Materiales de Madrid).
ABSTRACT:

The possibility of growing good quality oxide heterostructures has opened a vast field of research in which the electronic properties of strongly correlated systems may be modified on the nanoscale. In many occasions, the interface between two different oxides has properties different from the ones corresponding to the constituent layers in bulk. For instance, the interface between two insulating oxides (for instance, LaAlO3 and SrTiO3) can be metallic. New phases at interfaces have been observed in many different oxide multilayers. Different orders can arise due to the complexity of these materials in which the orbital degree of freedom, magnetism and lattice are strongly interdependent.
In this talk, I will present a joint theoretical-experimental effort to understand the

properties of a multilayer formed by a metallic ferromagnetic manganite oxide (La0.7Sr0.3MnO3) and the insulating SrTiO3.
Magnetoresistance measurements as a function of the relative angle between the magnetic field and the interface plane have shown an unexpected in-plane peak. Calculations of resistivity in a model system including spin-orbit coupling reveal that the unexpected in-plane maximum is due to transport through a two-dimensional system formed at the manganite interface. The magnetoresistance measurements thus expose the character of the electronic reconstruction occurring in this multilayer.
More information on IFIMAC Website

Cooper Pair Splitting as a Source of Entangled Electrons

Date: Monday, 16th December, 2013.



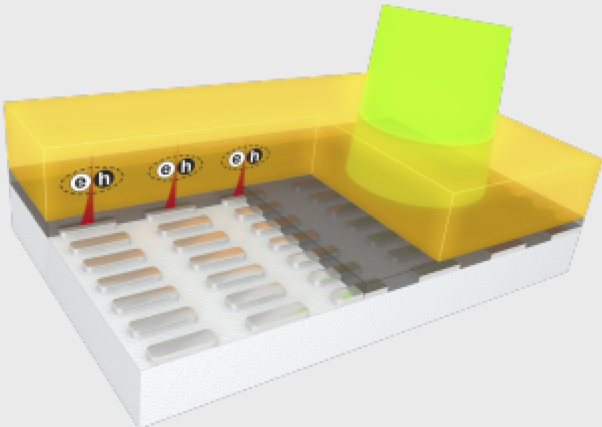
Time: 12:00h
Place: Departamento de Física Teórica de la Materia Condensada, Facultad Ciencias, Módulo 5 &, Aula de Seminarios (5ª Planta).
Jan Martinek (Institute of Molecular Physics- Polish Academy of Sciences).
ABSTRACT:

We study an entangled state of spatially separated electrons, in particular its spins, in a solid state electronic system. The ground state of conventional superconductors is a singlet state of electron Cooper pairs that can provide a natural source of entangled electrons.
One of the proposals to obtain the nonlocal entanglement of electrons is to use the Cooper pairs split in the Double Quantum Dot (DQD) system using the Coulomb interaction between electrons. We have analyzed an efficiency of the separation of Cooper pairs in systems, where the DQD is connected to the two superconducting leads, or to the superconducting and normal leads. Addressing the idea of quantum communication with entangled electrons in a solid state, where ferromagnetic detectors allow for spin correlation detection, we provide, using quantum information theory, a lower bond on the spin polarization of detectors. In ferromagnetic detectors the spin

information is transformed into charge information, however, any real magnetic materials feature imperfect spin polarization due to presence of both spin component in density of states at the Fermi surface. We find that lower bond for the spin polarization is p > 58 % for detection of entanglement using an optimal entanglement witness. It provides the minimal spin polarization of ferromagnetic materials that can be useful in quantum communication.
More information on IFIMAC Website

Thermalization and Cooling of Plasmon-exciton-polaritons: Towards Quantum Condensation

Date: Wednesday, 11st December 2013.



Time: 12:00h
Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta)
Johannes Feist (Departamento de Física Teórica de la Materia Condensada Universidad Autónoma de Madrid).
ABSTRACT:

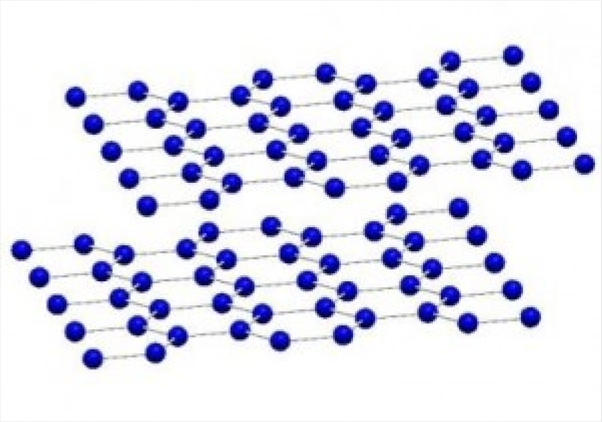
Condensation, where a single quantum state is macroscopically populated, lies at the heart of superfluidity, superconductivity, and Bose-Einstein condensation. A long-standing goal is to find systems that show condensation at higher temperatures than the well-known case of ultracold atomic gases, even at or above room temperature. Bosonic quasi-particles in solids are excellent candidates due to their low effective masses, and condensation has been observed for semiconductor exciton-polaritons, magnons and cavity photons.
I will present and discuss experimental signatures of thermalization and cooling, a precursor for condensation, of plasmon-exciton-polaritons (PEPs) at room temperature. The system consists of an array of metallic nanorods covered by an organic dye layer.

PEPs are formed by strong coupling between organic molecule excitons and surface lattice resonances (hybrid photonic-plasmonic states). The effective PEP mass is seven orders of magnitude below the electron mass and two orders of magnitude below exciton-polaritons in semiconductor microcavities. PEPs can be easily pumped and observed due to their photonic component. By increasing the PEP density through optical pumping, we observe signatures of thermalization and cooling, despite the nonequilibrium character of this driven and dissipative system. For increased pumping, we observe saturation of the strong coupling and emission in a new weakly coupled band, which again shows thermalization and cooling.

More information on IFIMAC Website

Ising Phase in AA Stacked Bilayer Graphene

Date: Friday, 29nd November (2013).



Time: 12:00h

Place: Departamento de Física de la Materia Condensada, Facultad Ciencias, Módulo 3 , Aula de Seminarios (5ª Planta)

Prof. Luis Brey (Instituto de Ciencia de Materiales de Madrid (CSIC), SPAIN).

ABSTRACT:

Recently it has become possible to fabricate AA-stacked bilayer graphene in real samples. AA-stacked bilayer graphene supports Fermi circles in its bonding and antibonding bands, which coincide exactly, leading to symmetry breaking in the presence of electron-electron interactions. This system bears a close resemblance to biased, double layer graphene (in which a strong barrier separates the two layers), which is believed to ideally support spontaneous exciton condensation due to perfect nesting of the Fermi surfaces. Layer bonding and anti-bonding states of the AA system play the roles of layer states of the double layer system, and in the former case the system has only Ising symmetry, whereas the latter has a U(1) symmetry. In this presentation we analyze the possibility that electron-electron interactions break the Ising symmetry and open a gap in the energy spectrum. We find that, in the mean field approximation, the ground state has a charge density wave character, with the charge modulation of each layer out of phase. We calculate the gap and the mean field critical temperature as a function of the strength of the Coulomb interaction, taking screening into account self-consistently with the calculation of the gap. We also analyze the transition between ordered and thermally disordered phases based on a continuum model, and find that the transition is controlled by an effective U(1) stiffness. We argue that in the limit of zero layer separation, for which the full U(1) symmetry of the Hamiltonian is restored, the Ising transition continuously goes into a Kosterlitz-Thouless transition.

More information on IFIMAC Website