REPORT

Workshop on:
“Electronic, transport and optical properties of low-dimensional systems”

The above mentioned workshop, supported by IUVSTA and the University of Valencia, has been held in Valencia (Spain) from the 31st of May to the 2nd of June 2010. During these 3 days, an intentionally limited number of participants (41 participants) has discussed on the hot topics on physics of low-dimensional systems defined in the guidelines of the scientific program.

These topics were:

- Optical, transport and conducting properties of low-dimensional materials.
- Angle-resolved Photoemission in low-dimensional materials.
- Photoelectron diffraction in surfaces.
- Molecular materials: Spin crossover materials. Multi-functional materials.
- Graphene and bilayer graphene: Electronic and transport properties. Doping. Devices. Many body effects.
- Novel topological states in matter: Topological Insulators.

As a summary, the workshop has been developed in the following venue and dates:

Place and date: Valencia, 31/05/2010-02/06/2010
Organizer: Juan Francisco Sánchez Royo.
Instituto de Ciencia de los Materiales de la Universidad de Valencia
Dpt. Física Aplicada y Electromagnetismo
Telf. 963544556
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e-mail: Juan.F.Sanchez@uv.es

More detailed information can be found in the **Website:** http://www.uv.es/wsetld/

In order to evaluate the magnitude and workframe of this Workshop, it would be interesting to analyze the profile of its participants. The 25% of the participants to the workshop did not present any contribution and all of them came from Spanish institutions. This profile contrasts with that of participants presenting an oral contribution: The 61% of participants came from Europe (22% from Spanish institutions and the rest from other European countries), the 7% from USA, the 5% from Japan, and the 2% from China. These facts evidence that this Workshop was eminently international and that produced a deep on the local community in the area of material research, motivated by the high-outstanding level of the speakers.

Economical Balance

Finally, I would like to present you an economical balance of this Workshop.

Expenses:

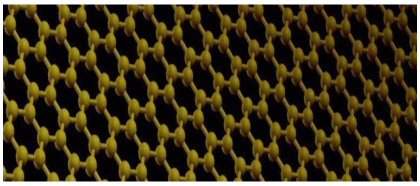
CONCEPT	AMOUNT (euros)
Renting Conference Hall	1.719,10
Assistant Staff (secretariat)	242,36
Bank expenses	1,36
Multi-media and Informatics	741,59
Office Material	57,59
Taxis and other transport for invited participants	135,61
Hotel invited participants	2.263,87
Workshop dinner	2.016,69
Lunch & catering (3 days)	1.840,61
Program and material for participants	1.446,52
Bus for social activities	300,00
Web page: creation and maintenance	1.250,00
TOTAL	**12.015,30**

Incomes:

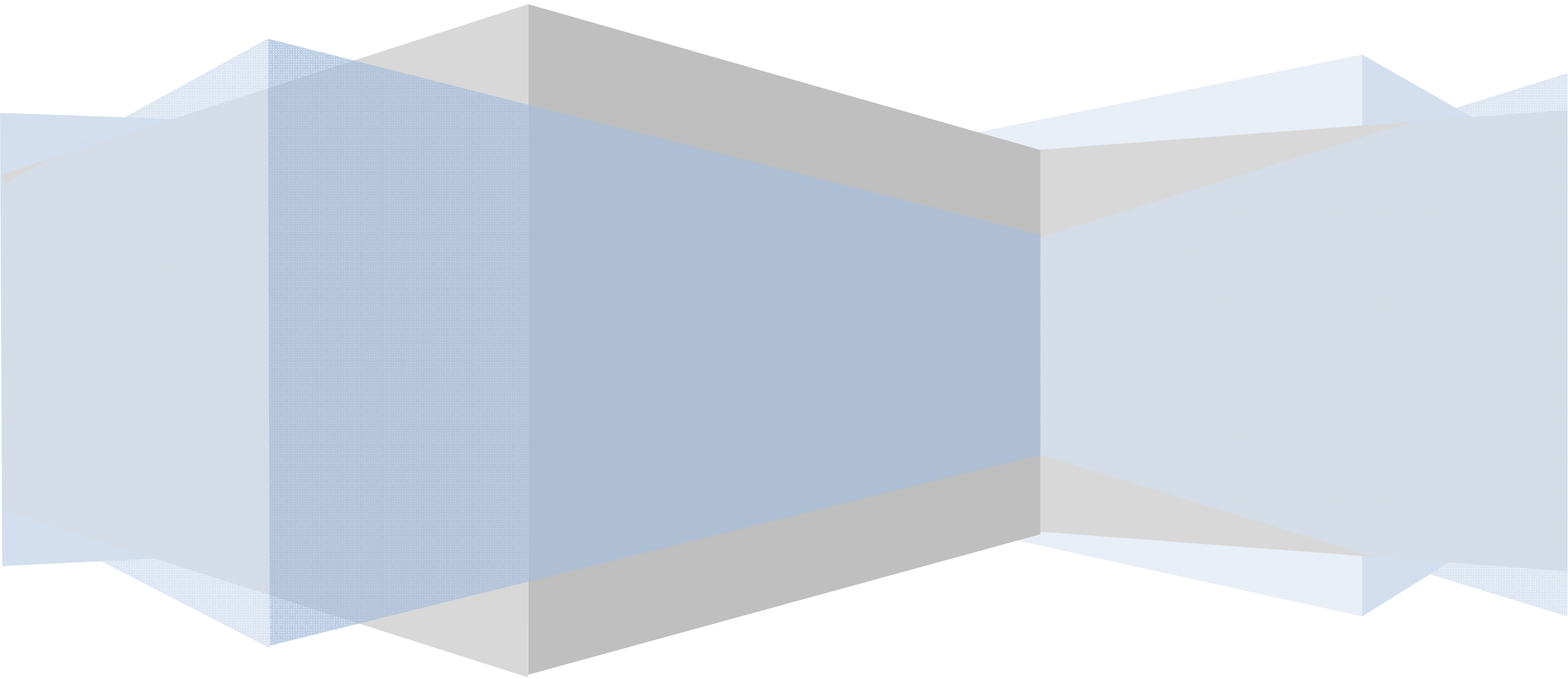
CONCEPT	AMOUNT (euros)
IUVSTA	6.000,00
University of Valencia	3.000,00
Registration fees (110 €/participant).	2.089,66
Contribution from Research Project	925,64
TOTAL	**12.015,30**

Electronic, transport, and optical properties of low-dimensional systems (WS10-ETOLDs)

Valencia, Spain, 31st May - 2nd June 2010



Program
& Abstract Book



Welcome to WS10-ETOLDs

Valencia, May 31 2010

Welcome to this Workshop on Electronic, Transport, and Optical Properties of Low-dimensional Systems (WS10-ETOLDs), held in Valencia from May 31 to June 2, 2010, at the University of Valencia.

This workshop will focus on key recent works establishing the connection between advanced materials and condensed matter physics. The structure of WS10-ETOLDs has been designed to stimulate exchange of ideas and international cooperation through a timely discussion of latest scientific results between theorists and experimentalists.

The WS10-ETOLDs is hosted by the International Union for Vacuum Science, Technique and Applications (IUVSTA) and the University of Valencia. The Workshop has received financial support from these two institutions. The organizers gratefully acknowledge their contributions, which have been indispensable in ensuring the success of the WS10-ETOLDs.

We gratefully acknowledge contributions from the International Advisory Committee in developing an exciting scientific program for WS10-ETOLDs.

We look forward to wonderful days of lively discussions and hope that you will enjoy your stay in Valencia.

Thank you very much for your attention,

Juan Francisco Sánchez Royo

Chairperson of the WS10-ETOLDs

Chairpersons and Committees

Executive Committee

Chairperson: Sánchez Royo, J.F. (University of Valencia, Spain).

Bolink, H. (University of Valencia).

Hernández Fenollosa, M. A. (Polytechnic University of Valencia).

Martínez Pastor, J. (University of Valencia).

Muñoz Sanjosé, V. (University of Valencia).

Real Cabezos, J. A. (University of Valencia).

Segura García del Río, A. (University of Valencia).

International Advisory Committee

Betti, M. G. (University La Sapienza, Italy).

Canadell, E. (ICMAB-CSIC, Spain).

Cantarero Sáez, A. (University of Valencia, Spain).

Coronado, E. (University of Valencia, Spain).

Le Lay, G. (CRMC2-CNRS, France).

Osterwalder, J. (University of Zurich, Switzerland).

Takahashi, T. (Tohoku University, Japan).

Taleb, A. (Synchrotron SOLEIL, France).

General Information
(http://www.uv.es/wsetld)

Venue

The WS10-ETOLDs will be held from May 31 to June 2, 2010, at the Ausias-March Residence in the coastal city of Valencia.

Colegio Mayor Ausias-March.
Av. Cataluña, 30
46021 Valencia. Spain
Telephone and fax:(+34) 963695408
E-Mail: colegiomayor@cm-ausiasmarch.com

The Workshop will be held in the Auditorium of Ausias-March Residence. The Auditorium has the most modern facilities for conferences.

Scientific Program

There will be no parallel sessions. All presentations will be oral and will take place at the Auditorium of the Ausias-March Residence. Invited and contributing talks will be in 35 and 25 min, respectively, including discussion.

Working language

The working language of WS10-ETOLDs is English and will be used for all printed materials, presentations, and discussions.

Telephone contact number

If you need to contact the organizers during the workshop, the following phone number will be available (+34) 656 320 730. Messages received by the Secretariat will be posted on the Message board at the Workshop venue.

Social program

Workshop banquet will be held on Tuesday, 1st June at 20:30 h in the La Pepica Restaurant. Buses to the restaurant will depart from the Renasa Hotel at 19:30 h.

Located in the proximity of the Port of Valencia, La Pepica is a reference in the traditional cook of the Valencia's region with more than 100 years of existence. Rice, fish and vegetables of the Valencia's land form the basis of its dishes accompanied with the best wines of the region.

Sponsors

We are very grateful to the following organizations for their financial contributions, as well as for their unrestricted support provided by different means to the WS10-ETOLDs.

International Union for Vacuum Science, Technique and Applications

University of Valencia

Workshop Program

Monday 31st May	**Tuesday 1st June**	**Wednesday 2nd June**
8:00- Registering		
8:15-8:30 Welcome		
8:30-9:05 T. Mallah	8:30-9:05 M. Z. Hasan	8:30-9:05 H.J. Gao
9:05-9:40 E. Coronado	9:05-9:40 S. Hasegawa	9:05-9:30 F. Prins
9:40-10:15 A. B. Gaspar	9:40-10:15 F. Meier	9:30-9:55 V. Zaporojtchenko
10:15-10:45 Coffee break	10:15-10:45 Coffee break	9:55-10:20 T. Fritz
10:45-11:20 C. Untiedt	10:45-11:20 S.-C. Zhang	10:20-10:50 Coffee break
11:20-11:45 A. Cantarero	11:20-11:55 H. Buhmann	10:50-11:25 J. Zúñiga
11:45-12:10 A. M. Lunde	11:55-12:30 Ph. Hofmann	11:25-11:50 A. Segura
12:10-12:35 J. Segura		11:50-12:15 R. Abargues
		12:15-12:40 G. Ferrari
		12:40 Closing Session
12.35-14.00 LUNCH	12.30-14.00 LUNCH	12:40-14:00 LUNCH
14:30-15:05 M. C. Asensio	14:30-15:05 K. Horn	
15:05-15:40 S. Souma	15:05-15:40 A. Bostwick	
15:40-16:15 G. Le Lay	15:40-16:05 J. Palacios	
16:15-16:45 Coffee break	16:05-16:30 C. Tegenkamp	
16:45-17:10 H. Pfnür	16:30-17:00 Coffee	
17:10-17:35 G. Muñoz		
17:35-18:00 K. Kolwas		
	20:30 Workshop Dinner	

Scientific Program

Monday 31 May, 2010

08:00 -	***Registering***
08:15 - 08:30	***Welcome***

Morning Session

Chaired by ***Jose Antonio Real (Valencia University, Spain)***

08:30 - 09:05	***Talal Mallah (University of Paris-Sud, France)*** Assembling Single Molecule Magnets on semi-conducting and magnetic surfaces
09:05 - 09:40	***Eugenio Coronado (Valencia University, Spain)*** Chemistry for Molecular Spintronics
09:40 - 10:15	***Ana Belén Gaspar (Valencia University, Spain)*** Multifunctionality in Spin Crossover Materials
10:15 - 10:45	***Coffee Break***

Chaired by ***Alfredo Segura (Valencia University, Spain)***

10:45 - 11:20	***Carlos Untiedt (Alicante University, Spain)*** Kondo Effect in a One-Atom Contact of a Ferromagnetic Material
11:20 - 11:45	***Andrés Cantarero (Valencia University, Spain)*** Micro-Raman scattering: a powerful tool for the physical characterization of semiconductor nanostructures
11:45 - 12:10	***Anders Mathias Lunde (University IFM Geneva, Switzerland)*** Interaction induced edge channel equilibration
12:10 - 12:35	***Jaime Segura Ruiz (Valencia University, Spain)*** Inhomogeneous electron distribution in InN nanocolumns
12:35 - 14:00	***Lunch***

Afternoon Session

Chaired by ***Philip Hofmann (University of Aarhus, Denmark)***

14:30 - 15:05	***Maria Carmen Asensio (SOLEIL Synchrotron, France)*** Typical Metal-Semiconductor Surface Phase Transitions: A revisit is needed
15:05 - 15:40	***Seigo Souma (Tohoku University, Japan)*** *Ultrahigh-resolution spin-resolved ARPES of novel low-dimensional systems*
15:40 - 16:15	***Guy Le Lay (CINaM-CNRS, France)*** *Silicene: the silicon based counterpart of graphene*

16:15 - 16:45 ***Coffee Break***

Chaired by ***Andrés Cantarero (Valencia University, Spain)***

Herbert Pfnür (Hannover University, Germany)
16:45 - 17:10 Anisotropic conductance oscillations and magnetotransport in Pb films on Si(557)

17:10 - 17:35 ***Guillermo Muñoz Matutano (Valencia University, Spain)***
Micro-Photoluminiscence from InAs/GaAs quantum dot pairs and molecules grown by droplet epitaxy

17:35 - 18:00 ***Krystyna Kolwas (Polish Academy of Sciences, Poland)***
Optical properties of gold and silver spherical plasmonic nanoantennas: size dependent multipolar resonance frequencies and plasmon damping rates

Tuesday 01 June, 2010

Morning Session

Chaired by ***Karsten Horn (Fritz Haber Institute, Germany)***

08:30 - 09:05 ***M. Zahid Hasan (Princeton University, USA)***
Discovery of several classes of Topological Insulators and related Superconductors using Spin-sensitive novel spectroscopic methods

09:05 - 09:40 ***Shuji Hasegawa (University of Tokyo, Japan)***
Surface states of Rashba-spin-split type and topological insulators

09:40 - 10:15 ***Fabian Meier (Paul Scherrer Institute, Switzerland)***
Spin and angle resolved photoemisson spectroscopy on topological insulators

10:15 - 10:45 ***Coffee Break***

Chaired by ***Aaron Bostwick (Lawrence Berkeley National Laboratory, USA)***

10:45 - 11:20 ***Shou-Cheng Zhang (Stanford University, USA)***
Topological insulators and topological superconductors

11:20 - 11:55 ***Hartmut Buhmann (Würzburg University, Germany)***
Topological Insulator States in HgTe

11:55 - 12:30 ***Philip Hofmann (University of Aarhus, Denmark)***
Electronic structure and electron dynamics in surfaces with strong spin-orbit splitting

12:35 - 14:00 ***Lunch***

Afternoon Session

Chaired by ***Hong-Jun Gao (Chinese Academy of Sciences, China)***

14:30 - 15:05	***Karsten Horn (Fritz Haber Institute, Germany)*** Electronic structure and many-body effects in graphene
15:05 - 15:40	***Aaron Bostwick (Lawrence Berkeley National Laboratory, USA)*** Plasmarons in Quasi-Freestanding Graphene
15:40 - 16:05	***Juan José Palacios (Alicante University, Spain)*** Quasi-universality of graphene minimal conductivity
16:05 - 16:30	***Christoph Tegenkamp (Leibniz University of Hannover, Germany)*** Plasmon damping and quasiparticle dynamics in epitaxial graphene
16:30 - 17:00	***Coffee***

Wednesday 02 June, 2010

Morning Session

Chaired by ***Talal Mallah (University of Paris-Sud, France)***

08:30 - 09:05	***Hong-Jun Gao (Chinese Academy of Sciences, China)*** Controlling Structural and Physical Properties of Quantum Molecular Systems at a Sub-molecular Level
09:05 - 09:30	***Ferry Prins (Delft University of Technology, The Netherlands)*** Transport through single spin-crossover nanoparticles
09:30 - 09:55	***Vladimir Zaporojtchenko (University of Kiel, Germany)*** Reversible electro-optical switchable effects in azomolecule containing nanocomposites
09:55 - 10:20	***Torsten Fritz (Friedrich Schiller University of Jena, Germany)*** Optical differential reflectance spectroscopy of ultrathin epitaxial organic films
10:20 - 10:50	***Coffee Break***

Chaired by ***Juan P. Martínez Pastor (Valencia University, Spain)***

10:50 - 11:25	***Jesús Zúñiga (CRHEA-CNRS, France)*** ZnO-based optical microcavities: from fabrication to strong-coupling
11:25 - 11:50	***Alfredo Segura (Valencia University, Spain)*** Optical measurements under high pressure in semiconductor nanostructures
11:50 - 12:15	***Rafael Abargues (Valencia University, Spain)*** Molecular Control of Plasmon Coupling in Self-Assembled Metal Nanoparticles
12:15 - 12:40	***Giulio Ferrari (University of Modena e Reggio Emilia, Italy)*** Prismatic core-shell nanowires: excitons and magnetic states
12:40 - 14:00	***Closing Session & Lunch***

Abstracts

Monday, 31 May 2010

Assembling Single Molecule Magnets on semi-conducting and magnetic surfaces

T. Mallah[a,*], G. Charron[a] , A. Giusti[a], P. Mialane[b], S. Palacin[c], W. Wersdorfer[d]

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Université Paris Sud 11, 91405 Orsay, France.
[b]Institut Lavoisier de Versailles, CNRS UMR 8180, Université de
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SCPCI, DRECAM, DSM, CEA Saclay
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Grenoble Cedex 9, France.

Magnetic bistablity has already been observed and widely investigated for magnetic complexes called Single Molecule Magnets (SMMs).[1,2] This behavior, observed at the level of a crystal, is due to molecular properties i.e. the presence of a high spin ground state and an easy-axis of magnetization for the individual molecules assembled within the crystal. In the perspective of designing information storage devices based on single magnetic molecules, one major challenge is to evidence the presence of the magnetic bistability at the level of individual molecules.

The next step consists in organizing the bistable molecules in ordered arrays to address them individually. To achieve these challenges, several problems must be overcome. Furthermore, the nature of the surface is important. Particularly the interface with the magnetic molecules may play a crucial role if model devices for molecular spintronics applications are considered. In this talk, we will present the assembly approach we used for two different SMMs on oxide and carbon surfaces.[3-7]

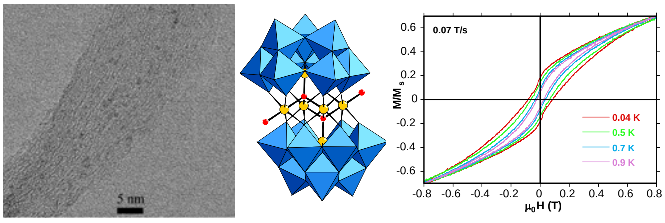

Figure 1. HRTEM (scale bar: 5 nm) of bundles of nanotubes decorated by the SMM polyoxoanion $[Fe_4(H_2O)_2(FeW_9O_{34})_2]^{10-}$ (Fe6-POM) (left), view of the structure of Fe6-POM (middle) and hysteresis loops at different temperatures for the isolated molecules grafted on SWNTs (right).

[1] R. Sessoli *et al.*, Nature **365**, 141 (1993).
[2] D. Gatteschi, and R. Sessoli. Angew. Chem. Int. Ed. **42**, 268 (2003).
[3] B. Fleury *et al.*, Chem. Commun., 2020 (2005).
[4] B. Fleury *et al.*, Inorg. Chem. **47**, 1898 (2008).
[5] B. Fleury *et al.*, Crystengcomm **11**, 2192 (2009).
[6] A. Giusti *et al.*, Angew. Chem. Int. Ed. **48**, 4949 (2009).
[7] G. Charron *et al.*, Nanoscale **2**, 139 (2010).

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Chemistry for Molecular Spintronics

E. Coronado, S. Cardona-Serra, C. Martí-Gastaldo, E. Navarro-Moratalla, J.P. Prieto-Ruiz, H. Prima-García

Instituto de Ciencia Molecular (ICMol).
Universidad de Valencia (Spain)

Spin-based electronics is one of the emerging branches in today's nanotechnology and the most active area within nanomagnetism. So far spintronics has been based on conventional materials like inorganic metals and semiconductors. Still, molecular electronics emerged several decades ago as a promising possibility to complement or even to replace conventional inorganic electronics when it goes nano. In this context, a natural evolution of molecular electronics is that of using magnetic molecules, as well as molecule-based materials, as components of new spintronic systems [1].

In this talk the important role that coordination chemistry can play in molecular spintronics in highlighted. I will present the major trends in this area, namely the development of spintronic structures incorporating molecular components, and the evolution towards single-molecule spintronics. I will focus on the design of new classes of magnetic molecular materials and magnetic molecules based on coordination chemistry which, conveniently nanostructured, can be of interest in molecular spintronics, quantum-computing and, in general, nanomagnetism. As magnetic molecular materials, I will focus on those exhibiting multifunctional properties, in particular those in which magnetism co-exist with electric conductivity. As magnetic molecules, I will focus on inorganic magnetic complexes based on metal-oxide clusters (polyoxometalates, POMs), which have shown to behave as molecular nanomagnets [2]. The chemical stability, together with the structural and electronic versatilities of POMs, will allow us to organize and address these molecules on metal surfaces. On the other hand, the use of these molecular metal-oxides as qubits in quantum computing will be discussed [3].

[1] Camarero, J; et al.., *J. Mater. Chem.* **2009**, *19*, 1678.
[2] AlDamen, M.A.; Clemente-Juan, J. M.; Coronado, E.; Martí-Gastaldo, C.; Gaita-Ariño, A., *J. Am. Chem. Soc.* **2008**, *130*, 8874; AlDamen, M. A.; Cardona-Serra, S.; Clemente-Juan, J. M.; Coronado, E.; Gaita-Ariño, A.; Martí-Gastaldo, C.; Luis, F.; Montero, O., *Inorg. Chem.* **2009**, *48*, 3467.
[3] Lehmann, J.; Gaita-Ariño, A.; Coronado, E.; Loss, D., *J. Mater. Chem.* **2009**, *19*, 1672.

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Multifunctionality in Spin Crossover Materials

A. B. Gaspar[a,*], J. A. Real[a], M. C. Muñoz[b], F. Muñoz-Lara[a],
M. Seredyuk[a], T. Romero-Morcillo[a]

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Having arrived at a reasonable understanding of how to control the spin transition processes[1] in solid material and, furthermore, with the recognition that spin crossover (SCO) compounds bear the potential for practical applications in switching and display devices,[2] recent activities in this field have been mostly devoted to the design of new SCO compounds in which SCO properties may be combined with other physical or chemical properties in a synergic fashion,[3,4] *e.g.* magnetic exchange,[5] liquid crystalline properties,[6] host-guest chemistry,[7] non-linear optics, electrical conductivity[8] and ligand isomerization.

Synergic systems with two or more phase transitions of different physical nature may lead to a number of advantages in practical applications, e.g. enhancement of spin transition signals, switching and sensing in different temperature regimes. Although the efforts in this area have commenced only recently, and much of the work is in progress, the current activities in our group regarding this topic will be presented and discussed.

[1] *"Spin Crossover in Transition Metal Compounds",* Eds. P. Gütlich, H. A. Goodwin, *Topics in Current Chemistry*, vol. **233-235** (2004**)**.
[2] a) A. Galet, et al., *Adv. Mater.*, **17**, 2949 (2005); b) O. Kahn, C. J. Martinez, *Science*, **279**, 44 (1998); c) O. Kahn, J. Kröber, C. Jay, *Adv. Mater.*, **4**, 718 (1992).
[3] J. A. Real, A. B. Gaspar, M. C. Muñoz. *Dalton Trans.*, 2062 (2005).
[4] A. B. Gaspar, et al., *Coord. Chem. Rev.,* **249**, 2661(2005).
[5] A. B. Gaspar, et al., J. Mat. Chem., 16, 2522 (2006).
[6] A. B. Gaspar, et al., *Coord. Chem. Rev.,* **253, 2399** (2009).
[7] a) G. Agustí, et al., *Angew. Chem. Int. Ed.*, **48**, 8944 (2009); b) M. Ohba, et al., *Angew. Chem. Int. Ed.*, **48**, 4767 (2009).
[8] S. Dorbes, L. Valade, J. A. Real, C. Faulmann, *Chem. Commun.*, 69 (2005).

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Kondo Effect in a One-Atom Contact of a Ferromagnetic Material

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M.R. Calvo[a], J. Fernandez-Rossier[a], J.J. Palacios[a], D. Jacob[b], D. Natelson[c], C. Untiedt[a,*]

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[b]Department of Physics and Astronomy, Rutgers University, Piscatway, NJ-08854, USA
[c]Department of Physics and Astronomy, Rice University, Houston, TX 77005, USA

The smallest object that we could connect to an electronic circuit will be formed by just a single atom. With the use of the Scanning Tunnelling Microscope (STM) and related techniques we can fabricate and modify atomic and molecular bridges in between two metallic electrodes. The conductance characteristics of atomic sized structures can give us information about the interaction of quasiparticles with the conduction electrons[1-4].

Here we report [5] on the existence of Kondo effect in ferromagnetic and perfectly homogeneous structures: atomic-size contacts of pure Fe, Co or Ni. The Kondo temperatures obtained from the Fano resonances of hundreds of contacts exhibit a logarithmic distribution that arises naturally from the Kondo theory. Moreover, The Fano features dissapear as the temperature increases, following the typical Kondo logarithmic trend. The Kondo effect appears in ferromagnetic atomic-size contacts as a consequence of their low dimensionality.

[1] I.K Yanson. Zh. Eksp. Teor Fiz. 66, 1035 (1974)
[2]C. Untiedt, G. Rubio-Bollinger, S. Vieira, N. Agraït. Phys. Rev. B 62, 9962 (2000)
[3]N. Agraït, C. Untiedt, G. Rubio-Bollinger, S. Vieira. Phys. Rev. Lett. ,88, 216803 (2002)
[4]R.H.M. Smit, Y. Noat, C. Untiedt, N.D. Lang, M.C. van Hemert, J.M. van Ruitenbeek. Nature 419, 906 (2002)
[5]R. Calvo, J. Fernandez-Rossier, J.J. Palacios, D. Jacob, D. Natelson, C. Untiedt. Nature 458, 1150 (2009)

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Micro-Raman scattering: a powerful tool for the physical characterization of semiconductor nanostructures

A. Cantarero

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Raman scattering (RS) is a powerful characterization tool of semiconductor nanostructures. It can provide a detailed information on several physical properties of the nanostructures and their constituents. In particular, we can infer the crystalline quality of the nanostructure, we can obtain information on the strain state of the constituents, or on size effects through phonon confinement. In doped semiconductors, we can extract information on the electron concentration via phonon-plasmon coupling. Furthermore, when the wavelength of the light is close to an electronic transition of the semiconductor (resonant Raman scattering), additional information on the band structure and quantum confined electronic states can be obtained. In this talk we will give an introduction of the Raman effect applied to the characterization of semiconductor nanostructures by means of a few examples of physical studies using Raman scattering as a fundamental tool.

Interaction induced edge channel equilibration

A. Mathias Lunde[a,b*], Simon E. Nigg[b] , Markus Büttiker[b]

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[b]Departement de Physique Theorique, Universite de Geneve, CH-1211 Geneve 4, Switzerland

Two decades ago, edge states in integer quantum hall systems [1] were demonstrated to be a physical reality by creating a non-equilibrium population [2] through selective injection and detection of carriers in different states along the same edge [3-5]. Now in a series of novel experiments the group of Pierre [6,7] has investigated the non-equilibrium distribution function in an edge state as it evolves along a channel away from a quantum point contact at which it is initially created. In the work presented here [8], we calculate the electronic distribution functions of two Coulomb coupled chiral edge states. They form a quasi-1D system with broken translation invariance and the distribution function is found using the equation of motion approach. We find that relaxation and thereby energy exchange between the two edge states is determined by the shot noise of the edge states generated at a quantum point contact. In close vicinity to the quantum point contact, we derive analytic expressions for the distribution functions. We further give an iterative procedure with which we can compute numerically the distribution functions arbitrarily far away from the quantum point contact. Our results are compared with the recent experiments [6,7].

[1] B. I. Halperin, Phys. Rev. B **25**, 2185 (1982).
[2] M. Büttiker, Phys. Rev. B **38**, 9375 (1988).
[3] S. Komiyama, et al., Phys. Rev. B **40**, 12566 (1989).
[4] B. J. van Wees, et al., Phys. Rev. Lett. **62**, 1181 (1989).
[5] B. W. Alphenaar, P. L. McEuen, R. G. Wheeler, and R. N. Sacks, Phys. Rev. Lett. **64**, 677 (1990).
[6] C. Altimiras, H. le Sueur, U. Gennser, A. Cavanna, D. Mailly, and F. Pierre, Nature Physics **6**, 34 (2009).
[7] H. le Sueur, C. Altimiras, U. Gennser, A. Cavanna, D. Mailly, and F. Pierre, arXiv:1003.4962 (unpublished) (2010).
[8] Anders Mathias Lunde, Simon E. Nigg, and Markus Büttiker, Phys. Rev. B **81**, 041311(R) (2010).

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Inhomogeneous electron distribution in InN nanocolumns

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J. Segura-Ruiz[a], A. Molina-Sánchez[a], N. Garro[a], A. García-Cristóbal[a], A. Cantarero[a], F. Iikawa[b], C. Denker[c], J. Mandriletos[c], and A. Rizzi[c]

[a]Materials Science Institute, University of Valencia, PO Box 22085, 46071 Valencia, Spain
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Up to recently, the bandgap of InN was believed to be in the visible region due to the Burstein shift produced by the high electron concentration. In recent years, molecular beam epitaxy (MBE) has allowed the growth high quality InN layers with a bandgap of 0.69 eV [1]. This low value and the high mobility of electrons make InN suitable for the development of infrared detectors and emitters. Since there is no lattice-matched substrate for crystal growth, one way to improve the crystal quality of InN is to grow nanocolumns (NCs). Columnar morphology favours lateral elastic relaxation and thus heterostructures allow a larger lattice mismatch than in layers before the formation of strain-related structural defects. Recently, high quality vertically self-oriented InN NCs have been obtained by plasma-assisted MBE [2]. The increased surface-to-volume ratio of the columnar morphology opens up new functionalities for these nanostructures and favours their use in optical sensors and solar cells. At the same time, enhanced effects of the surface electron accumulation layer on the properties of InN NCs are also expected. For instance, from conductance measurements [3], it is known that most of the electrical current goes through the surface of the NC.

In this work, Raman scattering, photoluminescence (PL), and photoluminescence excitation (PLE) spectra have been measured in a set of self-assembled InN NCs grown by plasma-assisted MBE on Si(111) substrates under slightly different conditions. Signatures of an inhomogeneous electron distribution inside the NCs have been found by analyzing the plasmon-phonon coupled modes [4]. The characteristics of the PL spectra could be explained by the inhomogeneous electron distribution within the NCs. We have reproduced the PLE experimental lineshapes by developing a theoretical model to calculate the absorption in a cylindrical InN NC. From the comparison with the experimental data the conduction band bending and Fermi energy can be obtained, which account for the differences among the PLE spectra of different samples.

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Typical Metal-Semiconductor Surface Phase Transitions: A revisit is needed

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The origin of surface phase transitions has been a matter of intense dispute among theoreticians and experimentalists, during the last years. The emergence of novel powerful techniques has made attainable a more truthful representation of those “well-known” traditional systems. The improved new pictures confirm that complex phenomena take place at surfaces originally described as simple model systems. In particular, notions as Peierls distortions, Fermi surface nesting, Jahn-Teller distortions, metal-insulator fluctuations, disproportionation and charge and spin density waves, have been pointed out as responsible mechanisms of reported Surface Phase Transitions. In this sense, pioneer studies have focused their attention on the traditional Pb or Sn adsorbed on Ge(111) surfaces, where several transitions have been reported and related to a wide range of diverse driving forces. In this talk, a comprehensive review of those phenomena will be presented.

Concerning the instrumentation, a special attention will be paid to microscopic techniques able to identify the role of heterogeneities at the surface phase transitions. It is manifest that the elevated flux of the third generation synchrotron radiation sources are essentially profited in the area of the X-ray microscopy. Now a day, those light sources are able to provide high brightness at micrometric or even nanometric beam sizes. In such context, photoemission microscopes will be introduced as tools capable to fill up the existing emptiness between the STM spectroscopy and the low-spatially resolved traditional ARPES and NEXAFS in the area of Surface Phase transitions.

NOTES

Ultrahigh-resolution spin-resolved ARPES of novel low-dimensional systems

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Low dimensional electron systems have been a target of intensive theoretical and experimental studies since they show a variety of intriguing physical phenomena. Recently, particular interest has been gathered in exotic spin-polarized electronic bands of material surfaces which has strong spin-orbit interaction. For deep understanding of those exotic spin state, we have developed an ultrahigh-resolution spin-resolved photoemission (PES) spectrometer with a mini Mott detector and a high-flux xenon plasma discharge lamp[1]. Spin polarized electrons are guided through a small hole near the multi channel plate at the exit of the hemispherical electron analyzer, and detected by a mini-Mott detector connected to a 90°-electron deflector. This configuration simultaneously enables the two-dimensional band structure mapping (energy *vs* momentum) and the spin detection along two principal axes (y and z). The spectrometer achieves an energy resolution of 8 meV for the spin-resolved measurement, one order of magnitude better than that of conventional equipments.[2,3] We present the spin-resolving performance of new spectrometer by an observation of clear Rashba splitting on the surface state of a Bismuth thin film.

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NOTES

Silicene: the silicon based counterpart of graphene

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Silicene [1], the counterpart of graphene for silicon, has attracted strong theoretical interest [2], since, if existing, it would reveal a cornucopia of new physics and potential applications: typically its charge carriers would be massless Dirac fermions.

Its synthesis has just been reported [3]: silicon deposition onto Ag(110) surfaces reveals the formation of silicon nano-ribbons (NRs) [4], in a massively parallel arrangement along the [-110] direction. Their atomic geometry was obtained through high-resolution STM images revealing a honeycomb arrangement, i.e., a silicene-like structure, further supported by Density Functional Theory calculations [3,5].

These 1D silicene NR's self-assemble by lateral compaction to form a grating with a pitch of ~ 2 nm covering the entire substrate surface [6]. Their electronic signature is a characteristic graphene-like dispersion at the 1D Brillouin zone extremities [7].

On the Ag(111) face, the deposition of Si gives rise to sharp LEED patterns, while STM investigations and high-resolution synchrotron radiation photoelectron spectroscopy measurements indicate as well the formation of well-ordered 2D silicon layers, which might be explained by the formation of silicene sheets.

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Anisotropic conductance oscillations and magnetotransport in Pb films on Si(557)

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The anisotropy induced by atomic steps of a Si(557) substrate in structure and magnetoconductance of ultrathin Pb films adsorbed on this surface is shown to be effectively shielded as a function of layer thickness, as found out by a combined study of low-energy electron diffraction and macroscopic four-point conductivity measurements as a function of Pb coverage, temperature, and magnetic field.

In strong contrast to flat Si(111), substrate steps effectively compensate the lateral misfit (10%), leading to crystalline growth starting from the first monolayer. Despite a large lattice mismatch, layer-by-layer growth is observed at 70 K, as most obvious from the characteristic oscillations in conductance with layer periodicity, incipient with the first monolayer both along and across the step direction. These findings demonstrate that lateral misfits (here almost 10%) in hetero-epitaxial systems can be effectively compensated by substrate steps and can change the growth mode with respect to flat surfaces. While structurally the layers appear to be isotropic starting already with the third layer, anisotropy is seen in transport up to at least six monolayers with functional dependencies of conductance varying with layer thickness and measurement direction. Maxima of conductance oscillations up to five monolayers do not coincide with completion of individual layers. They are characteristic for the close coupling of structure and quantum effects.

For well annealed layers, we find as a function of temperature that strong localization with clear anisotropy becomes dominant for coverages below 4 ML. Applying in addition a magnetic field up to 4 Tesla, also anisotropic magnetotransport was found caused by an enhanced elastic scattering rate in the direction perpendicular to the step direction. While multilayers are characterized by weak localization, antilocalization is found for all monolayer structures due to strong spin-orbit coupling, which is effectively switched off around 1 PML below 78 K, where one-dimensional transport was seen along the step direction[1].

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NOTES

Micro-Photoluminiscence from InAs/GaAs quantum dot pairs and molecules grown by droplet epitaxy

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We have investigated electric field dependence emission properties of single InGaAs/GaAs quantum dot pairs and molecules. These nanostructures were grown by droplet epitaxy [1]. This growth technique results in the formation of nanoholes where in-plane laterally aligned pairs of quantum dots (QDs) can be nucleated using the appropriate growth conditions. Compared with purely self-assembled methods, the droplet epitaxy technique allows to control separately the emission energy and nucleation density and produces good optical properties at the single QD level [2]. We have fabricated lateral electric field Schottky devices that allow to tune the energy levels of both QD and produce molecular coupling. We have found three different micro-photoluminiscence (micro-PL) pictures, attached to single QD, QD pair (not coupled) and QD molecule (coupled) systems. Single QD picture is related to the 2% of possibilities to obtain only one QD at each nanohole. QD pair micro-PL evolution was found when distance between both QDs is too large to produce strong molecular coupling. Finally, it was found asymmetrical micro-PL features, which are in good correspondence with a theoretical framework based on full CI (Configuration Interaction) calculations and effective mass approximations. Although clear anticrossing optical signatures were not identified, this signature of lateral molecular coupling is not easily found in literature [3, 4], the asymmetric Coulomb blockade QD charging and Stark effect gives valuable information to confirm the molecular coupled system [5].

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NOTES

Optical properties of gold and silver spherical plasmonic nanoantennas: Size dependent multipolar resonance frequencies and plasmon damping rates

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Absorbing and emitting optical properties of a spherical plasmonic nanoantenna are described in terms of the size dependent resonance frequencies and damping rates of the multipolar surface plasmons (SP). We provide the resonance frequencies and damping rates for gold and silver spherical particles as a function of their radius up to the large size retardation regime where the plasmon radiative damping is significant. We underline the role of the radiation damping in comparison with the energy dissipation damping in formation of receiving and transmitting properties of a plasmonic particle.

The size dependence of both: the multipolar SP resonance frequencies and corresponding damping rates is a convenient tool in tailoring the abilities of plasmonic nanoantennas for given application. It enables to control an operation frequency of a plasmonic nanoantenna in the range of about 1÷4 *eV* for silver and 1.2 ÷ 2.7*eV* for gold nanoparticles and to change the operation range from the spectrally broad to spectrally narrow and vice versa. It is also possible to switch between particle receiving (enhanced absorption) and emitting (enhanced scattering) abilities. Using the proper polarization geometry of observation it is possible to effectively separate the dipole and the quadrupole plasmon radiation from all the non-plasmonic contributions to the scattered light.

The spatial distribution of light intensity and the radial component of the electric field at the particle proximity were also acquired. Particle monochromatic images at frequencies close to and equal to the plasmon dipole and quadrupole resonance frequencies are discussed. The images resulted from the spatial distribution of the full mean Poynting vector which includes near-field radial components of the scattered electromagnetic field.

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Discovery of several classes of Topological Insulators and related Superconductors using Spin-sensitive novel spectroscopic methods

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The topological insulator is a fundamentally new phase of quantum matter, which exhibits exotic quantum-Hall-like behavior even in the absence of an applied magnetic field and unlike the quantum Hall liquids can be turned into superconductors [1]. In this talk, I will briefly review the first experimental discovery and realization of the topological insulator in Bi-Sb [2,3], and then report our discovery a new generation of topological insulators with order-of-magnitude larger bulk band gaps and a single spin-helical surface Dirac cone [4,5,6] and experimentally demonstrate *all* defining properties of topological insulators such as (1) Topological Spin-Textures [3,5,6], (2) Spin-momentum helical locking [3,6], (2) Non-trivial Berry's phases [3,6], (3) Absence of backscattering or no U-turn [5,7], (4) Protection by time-reversal symmetry [1,5], (5) Room temperature topological order [6], (6) Superconductivity and Magnetism in doped topological insulators [8,9].

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Surface states of Rashba-spin-split type and topological insulators

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Recently there has been growing interest in topological insulators or the quantum spin Hall (QSH) phase, which are insulating materials with bulk band gaps due to strong spin-orbit coupling, but have metallic edge states that are formed topologically and robust against any non-magnetic impurity. In a three-dimensional material, the two-dimensional surface states correspond to the edge states (topological metal) and their intriguing nature in terms of electronic and spin structures have been experimentally observed in bulk $Bi_{1-x}Sb_x$ single crystals and Bi_2Se_3, Bi_2Te_3. The Fermi surface of the surface states has a spin-chiral structure and spin-split bands crossing the Fermi level. Due to these features with time-reversal symmetry, backscattering of carriers is totally suppressed, which has been actually observed by scanning tunneling microscopy.

However, before the topological insulator came out, we did a lot of studies on the surface states of pure Bismuth thin films, using spin- and angle-resolved photoemission spectroscopy and surface-sensitive transport measurements [1-3]. It has turned out that the surface states show almost the same feature as that of $Bi_{1-x}Sb_x$ single crystals due to Rashba effect by strong spin-orbit coupling and broken inversion symmetry. Spin flow at the surface states, which is the unique feature of topological insulators, is not yet confirmed. In my talk, I will discuss the topological insulators based on our studies on pure Bi [1-3] and $Bi_{1-x}Sb_x$ [4], Bi_2Te_3 [5] alloy epitaxial thin films.

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Spin and angle resolved photoemisson spectroscopy on topological insulators

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The combination of spin-orbit interaction and broken spatial inversion symmetry can lead to a splitting of electronic states. The surface of a solid-state system naturally breaks the space inversion symmetry. Therefore spin polarization of surface states is common and spin and angle resolved photoemission spectroscopy is an ideal tool to study the spin structure of these spin-split surface states.[1] In this talk, I will highlight the capabilities of spin and angle-resolved photoemission spectroscopy. It will be shown that in combination with our two-step fitting routine we are able to precisely determine the spin polarization vector of electronic states in three dimensions.[2] Our analysis is of particular importance for systems without a global spin quantization axis and allows for a detailed characterization of subtle effects.

Case studies will be given among others for $Bi_{1-x}Sb_x$ and Bi_2Te_3, where spin polarization and spin texture could be measured for the first time on the surface of a topological insulator.[3,4] Further it will be shown that Bi(114) can be considered as a one-dimensional topological metal: the surface state is quasi one-dimensional and spin-split, with only one Fermi level crossing in the dispersive direction between Γ and X.[5]

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Topological insulators and topological superconductors

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Recently, a new class of topological states has been theoretically predicted and experimentally realized. The topological insulators have an insulating gap in the bulk, but have topologically protected edge or surface states due to the time reversal symmetry. In two dimensions the edge states give rise to the quantum spin Hall (QSH) effect, in the absence of any external magnetic field. I shall review the theoretical prediction [1] of the QSH state in HgTe/CdTe semiconductor quantum wells, and its recent experimental observation[2]. The edge states of the QSH state supports fractionally charged excitations [3]. The QSH effect can be generalized to three dimensions as the topological magneto-electric effect (TME) of the topological insulators [4]. Topological insulators Bi2Te3, Bi2Se3 have been discovered theoretically and experimentally to have surface states consisting of a single Dirac cone [5,6,7]. I shall present a realistic experimental proposals to observe the magnetic monopoles on the surface of topological insulators [8]. Topological superconductors and superfluid have been theoretically proposed recently [9], in both two and three dimensions. They have a full pairing gap in the bulk, and their mean field Hamiltonian look identical to that of the topological insulators. However, the gapless surface states consists of a single Majorana cone, containing only half the degree of freedom compared to the single Dirac cone on the surface of a topological insulators.

I shall discuss their physics properties and the search for these novel states in real materials.

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Topological Insulator States in HgTe

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The increasing understanding of topological phases in condensed matter physics, which was initiated by the quantum Hall effect, has inspired the search for other topological states, especially, in the absence of magnetic fields. As one example the quantum spin Hall (QSH) effect has been proposed for systems with time reversal symmetry and spin-orbit interactions [1,2]. In a two-dimensional system this new state is characterized by an insulating bulk and two counter-propagating helical edge states. These Kramers pairs fulfill time reversal symmetry and account for a quantized conductance and spin currents propagate without dissipation. It turned out that HgTe-based quantum well (QW) structures are most suitable candidates for a successful experimental realization [3].

In this presentation, the HgTe QW band structure properties and experimental requirements are discussed which lead to the observation of quantized spin polarized edge channel transport, one of the main signatures of the QSH effect [4,5]. Experiments will be presented that demonstrate the stability of the quantized conductance and its non-local character [6]. Furthermore, it is possible to show evidence for the spin polarization of the QSH edge channels in an all-electrical measurement which demonstrates the potential of the QSH effect for possible spin injection and detection application in spintronics devices. Perspectives for the realization of 3D topological insulator states in bulk HgTe are discussed.

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Electronic structure and electron dynamics in surfaces with strong spin-orbit splitting

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Symmetry breaking at the surfaces of heavy metals leads to surface-localized electronic states which show strong spin-orbit splitting, even if the bulk states are degenerate because of inversion symmetry. Lifting the spin degeneracy in the states gives rise to a number of interesting effects in the electronic structure, electron lifetimes and scattering dynamics and the states can also be used as model systems for similar physics observed on the surfaces and edges of topological insulators. This is especially useful in the case of the group V semimetals Sb and Bi which have a low density of bulk states at the Fermi energy and therefore constitute a quasi two-dimensional metal, on the verge of actually being a topological insulator. This presentation gives recent examples of electronic structure and lifetime investigations on such surfaces, with special focus on the semimetals Sb and Bi.

NOTES

Electronic structure and many-body effects in graphene

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Graphene, the single layer of hexagonally coordinated carbon [1], is of great interest from a fundamental as well as applications-oriented point of view due to its unusual electronic structure (charge carriers being “massless Dirac Fermions”) [2]. Here we examine the band structure using angle-resolved photoemission in order to provide a detailed description of its valence level states in the vicinity of the Fermi level and the so-called “Dirac point”. We follow the evolution of the band structure from the single layer towards bulk-like behaviour, with special attention to the bilayer where gap opening is observed as a function of doping [3]. The effect of many-body processes on the spectral function can be followed in great detail because of its simple band structure, permitting the investigation of the influence of electron-phonon, electron-electron and electron-plasmon interaction on the spectral function [4]. In the latter case, we find a new “plasmaron” quasiparticle where the hole state is dressed by collective excitations of the electron gas. The influence of a very low concentration of hydrogen-induced defects is shown to give rise to a metal-insulator transition that has marked influence on the spectral function, signaling a breakdown of the quasiparticle picture [5]. Graphene is shown to be ideally suited for studies of the electronic structure of “matter in 2 dimensions”.

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Plasmarons in Quasi-Freestanding Graphene

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Graphene is a remarkable new electronic material with many unique properties. To realize its promise, it is essential to understand how its charge carriers interact. By measuring the spectral function of charge carriers in quasi-free-standing graphene, we show that at finite doping, the well-known linear Dirac spectrum does not provide a full description of the charge-carrying excitations. We report that there also exist composite "plasmaron" particles, consisting of particles dressed by density oscillations of the graphene electron gas. The Dirac crossing point is resolved into three crossings: the first between pure charge bands, the second between pure plasmaron bands, and the third a ring-shaped crossing between charge and plasmaron bands.

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Quasi-universality of graphene minimal conductivity

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The ensuing years after the first reported transport measurements of isolated graphene flakes have witnessed an intense debate on the origin of the quasi-universal value of its minimal conductivity. It is a fact that the minimal conductivity of most graphene samples is larger than the well-established universal value for ideal graphene $4e^2/\pi h$; in particular, larger by a factor in the vicinity of π. Despite intense theoretical activity, this fundamental issue has eluded an explanation so far. Here I will present fully atomistic quantum mechanical estimates of the graphene minimal conductivity where electron-electron interactions are considered in the framework of density functional theory. I will show the first conclusive evidence of the dominant role on the minimal conductivity of charged impurities (see figure) over ripples, which have no visible effect. Furthermore, in combination with the logarithmic scaling law for diffusive metallic graphene, I ellucidate the origin of the narrow range of observed minimal conductivity values[1].

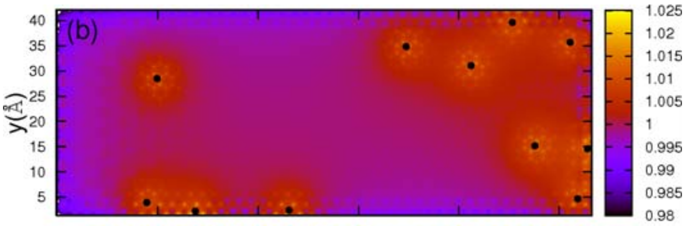

Figure: An example of the graphene screening charge density induced by charged impurities placed 5 A off the graphene plane (black dots).

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Plasmon damping and quasiparticle dynamics in epitaxial graphene

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The sheet plasmon in epitaxially grown graphene layers on SiC(0001) and the influence of surface roughness have been investigated in detail by means of low-energy electron diffraction (LEED) and angle resolved electron energy loss spectroscopy (EELS).

We show that the existence of steps or grain boundaries in this epitaxial system is a source of strong damping, while the dispersion is rather insensitive to defects. To the first order, the lifetime of the plasmons was found to be proportional to the average terrace length and to the plasmon wavelength. A possible reason for this surprisingly efficient plasmon damping is the close coincidence of phase (and group) velocities of the plasmons (almost linear dispersion) with the Fermi velocity of the electrons. Therefore, uncorrelated defects like steps only have to act as a momentum source to effectively couple plasmons to the electron–hole continuum by intraband transitions [1].

Regarding the plasmon dispersion the opening of the interband loss channel appears as a characteristic upward shift in the plasmon dispersion and a dip in addition in the width of the loss peak, which is explained as a resonance effect in the formation of electron-hole pairs. The importance of quasiparticle dynamics was demonstrated recently in a complementary angle resolved photoemission experiment [2]. This resonance effects has been systematically studied as a function of temperature, intrinsic defects, influence of multilayers and adsorption of F4-TCNQ molecules. Despite the existence of strong electronic correlations, the plasmonic dispersion can be quantitatively described within the framework of a nearly free electron gas [3].

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Controlling Structural and Physical Properties of Quantum Molecular Systems at a Sub-molecular Level

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Constructing molecular aggregates of functionalities and controlling the physical properties have stimulated a great interest in the past decades. One of the challenges in this field is to make the single molecule stably connected to a single metal atom on metal surfaces, and further to make the molecule create electric energy and optical/electro radiation by rotating the molecule. In this talk, I will present that by using Au adatoms of the Au(111) surface we have successfully formed a single molecule rotor array, isolated tetra-*tert*-butyl Zinc Phthalocyanine ((t-Bu)$_4$-ZnPc) molecules sticking to the Au adatoms of the Au(111) and rotating on the surface at 78 K. This kind of single molecular rotor was also found to be controlled by the different sites of the Au(111) surface using low temperature scanning tunneling microscopy (STM). On the other hand, changing the molecular structure by using the same molecular family of the Pc, ZnPc and FePc, can also modulate the rotation behavior of the molecules. A further study of single FePc molecule on Au(111) substrate show that both the Kondo temperature and the line shape of *dI/dV* spectra are greatly influenced by molecular adsorption configuration on the Au(111) substrate. This implies that it is feasible to control the local spin coupling and the competition between different tunneling channels in molecular Kondo effect by changing the molecular adsorption configuration. Given that the lateral structure of a molecular interface can be modified by the attachment of ligands, our results will be helpful for opening up the possibility to tailor physical properties of a single molecule or molecular aggregates to the desired specifications.

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Transport through single spin-crossover nanoparticles

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Molecular electronics has the potential to profit from specific molecular functionalities. To date, high intrinsic resistivity of most molecular materials have largely limited this to devices based on pi-conjugated systems.

Here we report on a conceptually new way of electrically addressing functional molecular-materials by using molecular nanoparticles placed in between nanometer-spaced electrodes.[1] The emerging field of molecular nanoparticles has shown the possibility of scaling down the size of molecular materials, while maintaining their bulk properties.[2] In this study we use particles based on a spin-crossover polymer, which undergo a hysteretic phase-transition above room temperature.[3]

We will show that with our technique it is possible to make electrical contact to individual particles. Low temperature characterization reveals that transport across the particles is defined by single-electron tunneling events. Moreover, the spin-crossover properties of the particles are maintained and reflected in the transport characteristics.

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Reversible electro-optical switchable effects in azomolecule containing nanocomposites

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We report on the electro-optical properties of metal-polymer nanocomposite films [1] based on polymer thin films with dissolved azobenzene chromophores. These molecules perform a cis-trans isomerization upon illumination, accompanied by a significant change in molecular length and dipole moment. We examined the isomerization and the time dependence in optical switching with UV and visible light of an azobenzeneether dissolved in a PMMA matrix in combination with quasi-two-dimensional Pt and Au nanoparticle arrays embedded in polymer. A high chromophore concentrations (~ 40 wt %) and stability with respect to crystallization was obtained by using molecules with branched tails. The chromophore/polymer film was prepared by spin-coating and the metal clusters were deposited either by thermal evaporation or via sputtering and subsequently embedded into the polymer matrix [3]. This procedure was used to prepare a two-dimensional nanoparticle network close to percolation threshold [2]. The morphology of the nanocomposites was studied with TEM and AFM. The electro-optical properties of these composites can be changed reversibly upon illumination with UV (360nm) and visible light (450nm), due to the reversible conformational change of the switchable azomolecules [4]. We discuss the reversible photo-switchable changes in DC conductance of a two-dimensional nanoparticle network as well as light induced AC impedance variation in sandwich structures of the nanocomposite. We discuss also switching effects in films which were illuminated under heat treatment. Molecular re-orientation and motions at different temperature around Tg of the polymer matrix also was studied.

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Optical differential reflectance spectroscopy of ultrathin epitaxial organic films

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Optical techniques are especially suitable for investigating organic thin films, as they are mostly non-intrusive and can hence be applied *in situ* as a real-time monitoring method. Due to the strong structure-properties-dependence of organic materials optical spectroscopy can even been employed to gain structural information.

Differential reflectance spectroscopy (DRS) arises from common reflectivity measurements. It is simply defined as:

$$DRS \equiv \frac{\Delta R}{R}(E,d) := \frac{R(E,d) - R(E,0)}{R(E,0)} , \quad (1)$$

utilizing the change in reflectance between a sample with ($R(E,d)$, d = film thickness) and without ($R(E,0)$) adsorbate, normalized by $R(E,0)$ [1].

In our contribution we will give an overview on optical reflectance spectroscopy of highly ordered organic thin films in the thickness range from submonolayers to several monolayers, as a tool to study the light absorption behavior of such films. By doing so, we will emphasize the relations between the physical layer structure and the resulting optical properties. More specifically, we intend to show on the basis of particular examples what physical effects can be favorably examined by means of real-time optical spectroscopy, i.e., applied during the actual film growth [2].

Epitaxial organic films on inorganic substrates (insulators and conductors) will be in focus, and also the perspectives of investigating organic–organic heteroepitaxial layers will be addressed. Further, we will demonstrate that by means of DRS even the charging of organic molecules upon doping can be unambiguously detected [3].

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ZnO-based optical microcavities: from fabrication to strong-coupling

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ZnO is a wide bandgap material with an emission energy in the UV range that can be tuned further into the UV by alloying it with Mg or into the visible if alloyed with Cd. Furthermore, due to its large exciton binding energy (larger than the thermal energy at room temperature) and large oscillator strengths, ZnO appears as a natural candidate for fabricating optical microcavities working in the strong coupling regime and achieving polariton lasing at room temperature.

In this work we report on the growth of ZnO thin films by plasma-enhanced molecular beam epitaxy on GaN, AlGaN and AlN buffer layers, themselves grown on Si(111) substrates. It will be shown that upon optimized growth conditions, two-dimensional ZnO films with surface roughness in the order of 1-2 nm and high structural quality can be achieved on top of the nitride buffer layers. These ZnO films provide the active medium for our optical microcavities, which are completed by a nitride-based distributed Bragg reflector (DBR) as lower mirror, and a metallic or dielectric DBR as upper mirror.

After presenting the structural and morphological properties of the optical cavities, we will discuss the effects of the mirrors as well as of the optical thickness on the value of the Rabi splitting, which is a measure of the coupling strength. In these cavities the Rabi energies range so far from 35meV to 130meV [1-2]. Due to these large Rabi energies and the narrow stop-band of the underlying nitride DBRs, strong coupling to Bragg modes is observed. The consequences of this coupling, which leads to the appearance of several "lower polariton branches", on polariton relaxation will be discussed [3].

Finally, we will present our latest attempts to increase the cavities quality factor by using novel cavities designs.

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Optical measurements under high pressure in semiconductor nanostructures

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Even if transport measurements have been widely used in high pressure research since the foundational period [1] and have been applied to semiconductor physics since the very beginning [2], since the appearance of the diamond anvil cell and the ruby scale [3], optical spectroscopy under high pressure has been one of the most fruitful techniques in yielding rich and accurate information on the electronic structure of bulk and nano-structured semiconductors [4].

In this talk we will first discuss how high pressure optical spectroscopy techniques can be applied to study of the electronic structure of semiconductor nanostructures and then we will focus in some particular cases like PbSe and ZnCoO nanoparticles or InAs nanowires.

In the case of PbSe nanoparticles we will show how optical measurements under pressure can help to evaluate the effect of different electronic parameters on the exciton confinement energy. In the case of ZnCoO we will show how the effect of the surface energy can change the structure phase phase diagram of nanoparticles (with respect to the bulk semiconductor) and give a wide range of phase metastability, through which ZnCoO can be found in both the wurtzite and rock-salt phase.

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NOTES

Molecular Control of Plasmon Coupling in Self-Assembled Metal Nanoparticles

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Noble metal nanoparticles (NPs) have attracted much attention in the last years because of their amazing optical properties which arise from an electrodynamic phenomenon known as localized surface plasmon resonance (LSPR). It is well established that light at the LSPR frequency interacts strongly with noble metal NPs and excites a collective electron motion which produces an oscillating dipole field. Optical properties of noble metal NPs are mainly determined by particle geometry (size and shape) and surrounding environment, such as, the proximity to other particles. When metal NPs are placed in close proximity the dipole field generated in a NP by plasmon excitation induces plasmon oscillation in the neighboring NPs via near-field electrodynamic interactions. This phenomenon is known as interparticle plasmon coupling [1]. The EM field generated between NPs is enhanced several orders of magnitude. As a result, the LSPR of two coupled NPs is splited into two plasmonic modes when excited by incident electromagnetic radiation: a strongly red-shifted dipole-active mode for external fields oriented along the interparticle axis and a blue shifted mode for perpendicular orientations. Plasmon coupling strongly depends on the interparticle distances in the assembly as well as on the number, size and shape of coupled NPs. The strong EM field enhancement in the vicinity of noble particles shows a great potential for biological and optoelectronic applications [2]. However, exploiting the field enhancement offered by plasmonic assemblies is limited by lack of a simple method that can generate these nanostructures with controlled interparticle spacing and regularity.

We report on a novel and simple method for the synthesis of assemblies of NPs with tunable optical properties. The synthetic route used is based on the covalent binding among NPs by means of bifunctional molecular linkers of variable chain lengths. For such a purpose we synthesized OH-terminated NPs as building blocks which can systematically react with different dicarboxylic acids to form clusters of NPs of variable length and morphology. As a result, the initially symmetric LSPR band splits into two plasmonic modes. The formation of the Ag and Au NP agglomerates was followed by UV-Vis spectroscopy and TEM. We demonstrate that this method is suitable to control of the plasmon coupling among NPs with the interparticle spacing and the assembly size.

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NOTES

Prismatic core-shell nanowires: excitons and magnetic states

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Excitons in core-multishell semiconductor nanowires (NWs) are studied by modelling the electronic and optical properties of dielectrically mismatched heterostrucures grown around a prismatic NW core, where the carriers are confined in a quasi-2D shell at the interface between different materials [1]. We calculate the strength of the exciton binding energy for different materials and structure parameters, showing a dependence of the optical characteristics on the shape and size of the core-multishell NWs. We also highlight the effect of an applied magnetic field, in an arbitrary direction, on the single particle states.

With the recent progress in growth techniques, prismatic core-multishell NWs have been experimentally realised [1], where 2D electronic states are formed at the interface between different shells, due to the band offset. The edges of the prismatic 2D shell are known to be regions of preferred localisation [1,2], so that there will form 1D channels which will enhance the exciton binding energy significantly due to confinement.

We have implemented a realistic model of the NWs, including the effect of the prismatic symmetry through a geometric potential at the edges [2] that gives rise also to the formation of the 1D channels. We have also introduced a dielectric modulation between the core and the shells to take into account the screening provided by the dielectric environment. We simulate the electric and optical properties by the direct diagonalisation of an effective mass Hamiltonian and using the exact Green's function of Poisson's equation for a cylindrical shell. Although this versatility allows us to provide simulations for a large range of experimentally realised NWs, here we show results for hexagonal core-multishell NWs but with a realistic dielectric mismatch. Our calculations show that excitons are more strongly bound if the NW edges are sharper and that this effect is stronger for NWs with larger diameters.

We have also included an axial magnetic field [3], in an arbitrary direction. We show the appearance of Aharonov-Bohm oscillations and the formation of Landau levels on the interface between different semiconductor materials, depending on the NW parameters, as the diameter, edge sharpness, dielectric material constants and the direction of the applied magnetic field.

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