ICMM 2012 – ORLANDO

TUTORIALS SESSION – Sunday, 7 October 2012

Schedule

8:00am (Shutle departs from the Rosen Centre - *free for hotel guests*)

TUTORIALS AT UCF - PHYSICAL SCIENCE BUILDING (4000 Central Florida Blvd. Orlando FL 32816)

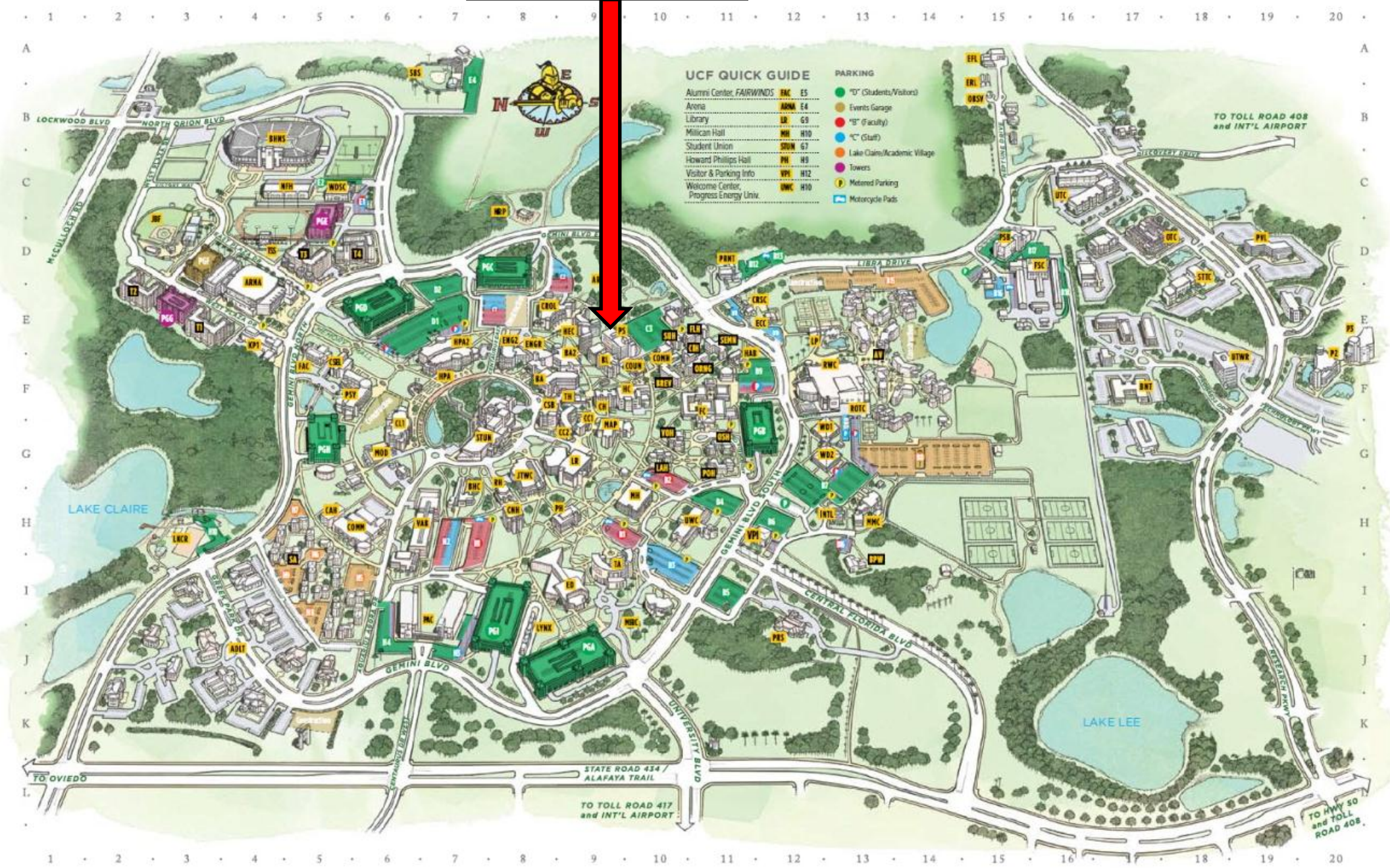
9:00am-9:30am	*breakfast*	
9:30am-10:30am	**ST-1: Andrew Kent** *New York University/USA*	An Introduction to Quantum Tunneling of the Magnetization and Magnetic Ordering in Single Molecule Magnets
10:30am-11:30am	**ST-2: Rodolphe Clerac** *CRPP-CRNS/France*	Introduction to Single-Chain Magnets and related systems
11:30am-12:30pm	**ST-3: Natia Frank** *University of Victoria-Canada*	Magnetoconducting Materials Based on Organic Spin Carriers
12:30pm-1:30pm	*Jimmy John's lunch*	
1:30pm-2:30pm	**ST-4: Herre van der Zant** *TU-Delft/Nederlands*	Transport through (magnetic) nanoscale objects
2:30pm-3:30pm	**ST-5: Michael Shatruk** *Florida State University/USA*	Spin Crossover in Transition Metal Complexes
3:30pm-4:30pm	**Open table:**	Students - Faculty discussion *(coffee served)*

4:30pm (shutle back to the Rosen Centre)

Stop by the ICMM Registration Desk at the Rosen Centre to check-in and get your name badge and conference items (open until 7pm)

7:00 pm Welcome Reception at Rosen School of Hospitality

PHYSICAL SCIENCE BUILDING
Room 161



ST-1

An Introduction to Quantum Tunneling of the Magnetization and Magnetic Ordering in Single Molecule Magnets

Andrew D. Kent

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This tutorial will provide an introduction to the magnetic characteristics of single molecule magnets (SMMs). SMMs represent a molecular or 'bottom-up' approach to nanomagnetism, with advantages that include chemical control of molecular structure, spin, magnetic anisotropy as well as intra- and intermolecular magnetic interactions. They display properties of much larger ferromagnetic particles prepared by conventional lithographic methods but in a manner that has enabled fundamental physics studies. For example, quantum tunneling of the magnetization (QTM) has been clearly demonstrated and studied in great detail in these materials. The fundamentals of QTM will be discussed along with some of the key and illustrative experimental results. SMM single crystals have also enable realization of the transverse field Ising model, in which quantum fluctuations associated with a transverse applied field complete with dipolar (and other magnetic) intermolecular interactions that favor long range magnetic order. Long-range magnetic order and quantum fluctuation will also be a subject of this tutorial, with the aim of providing background to understanding recent developments in the field, including results that will be presented at the ICMM.

ST-2

Introduction to Single-Chain Magnets and related systems

Rodolphe Clerac

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In the last twenty years, considerable research effort has been devoted to the synthesis of nanometer scale magnetic systems with the ultimate goal to reduce the size of the magnetic units that store information. Different approaches have been used to obtain single-domain magnetic particles, but the beginning of the 1990's marked the discovery of Single-Molecule Magnets (SMMs)[1] which created the hope to store information on a single molecule [2]. In the 20 years since, numerous Single-Molecule Magnets have been discovered and a broad community currently works on new systems with improved magnetic characteristics. About tens years ago, one-dimensional (1-D) systems [3], termed Single-Chain Magnets (SCMs)[3b,4], have been discovered to exhibit slow relaxation of the magnetization (i.e. magnet behavior) and thus magnetic properties comparable to SMMs. In this tutorial, we will focus on the magnetic properties of Single-Chain Magnets and related systems, summarizing the current knowledge on a theoretical point of view and illustrating the different aspects with selected experimental data.

References:

[1] *(a) P. D. W. Boyd, Q. Li, J. B. Vincent, K. Folting, H.-R. Chang, W. E. Streib, J. C. Huffman, G. Christou and D. N. Hendrickson, J. Am. Chem. Soc., 1988, 110, 8537; (b) A. Caneschi, D. Gatteschi and R. Sessoli, J. Am. Chem. Soc., 1991, 113, 5873; (c) R. Sessoli, H.-L. Tsai, A. R. Schake, S. Wang, J. B. Vincent, K. Folting, D. Gatteschi, G. Christou and D. N. Hendrickson, J. Am. Chem. Soc., 1993, 115, 1804; (d) R. Sessoli, D. Gatteschi, A. Caneschi and M. A. Novak, Nature 1993, 365, 141; (e) L. Thomas, F. Lionti, R. Ballou, D. Gatteschi, R. Sessoli and B. Barbara, Nature, 1996, 383, 145; (f) D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, Oxford, 2006.*

[2] *(a) M. N. Leuenberger and D. Loss, Nature 2001, 410, 789; (b) L. Bogani and W. Wernsdorfer, Nature Materials, 2008, 7, 179; (c) M. Afronte, J. Mater. Chem., 2008, 19, 1731; (d) R. E. P. Winpenny, Angew. Chem. Int. Ed., 2008, 47, 7992; (e) W. Wernsdorfer, C. R. Chimie, 2008, 11, 1086; (f) M. Mannini, F. Pineider, P. Sainctavit, C. Danieli, E. Otero, C. Sciancalepore, A. M. Talarico, M.-A. Arrio, A. Cornia, D. Gatteschi and R. Sessoli, Nature Materials, 2009, 8, 194.*

[3] *(a) A. Caneschi, D. Gatteschi, N. Lalioti, C. Sangregorio, R. Sessoli, G. Venturi, A. Vindigni, A. Rettori, M. G. Pini and M. A. Novak, Angew. Chem., Int. Ed., 2001, 40, 1760; (b) R.Clérac, H. Miyasaka, M. Yamashita and C. Coulon, J. Am. Chem. Soc., 2002, 124, 12837.*

[4] *C. Coulon, H. Miyasaka and R. Clérac, Struct. Bonding, 2006, 122, 163; H. Miyasaka, M. Julve, M. Yamashita and R. Clérac, Inorg. Chem., 2009, 48, 3420*

ST-3

Magnetoconducting Materials Based on Organic Spin Carriers

Natia L. Frank

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Interest in combining magnetic, electrical, or optical properties into one material capable of interfacing distinct forms of data manipulation has led to recent activity in the exploration of multifunctional materials. A particularly attractive goal is the design of molecular materials that allow exploration of magnetism-conductivity relationships in mesoscopic systems central to the burgeoning areas of spintronics. The idea of using spin for electronics has received strong experimental support in which unusually long spin-dephasing times in semiconductors approaching microseconds, the injection of spin-polarized currents from a magnetic- to non-magnetic semiconductors, and phase-coherent spin transport over distances of up to 100 m have been observed.

Early developments in magneto-conducting materials involve investigation of molecular conductors in which the conduction electrons and localized magnetic moments are associated with separate and distinct sublattices. An alternative approach is the investigation of single component systems in which both magnetic and conducting properties arise from the same molecular framework. Such systems, have provided interesting insight into the complexity of magnetism-conductivity relationships in molecular materials. The interaction of local moments with conduction electrons has been explored in quasi 1-D conductors of metal phthalocyanines which form π-stacks in the solid state. It has been suggested that the principal magnetic interaction occurs between Cu(II) ions through an indirect exchange mechanism mediated by the conduction electrons. Other members of the molecular class are less well understood. For example, a class of alkyl substituted spiro-biphenalenyl radicals display interesting conducting and magnetic properties which are not always well-correlated. This highlights the need for further exploration of the fundamental relationships between magnetism and conductivity in molecular materials.

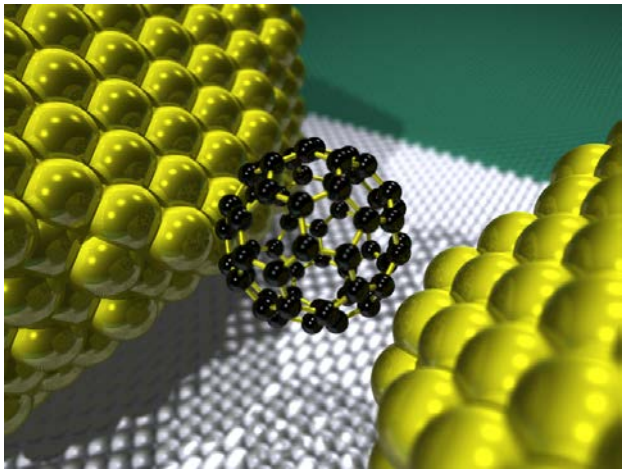
ST-4

Transport through (magnetic) nanoscale objects

Herre van der Zant

Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands

During the last few years different techniques have become available to study electrical transport through an individual nano-object. Electromigration, mechanically-controlled break junctions and scanning probes are examples of such techniques. The objects of interest are mostly individual molecules and nanoparticles; they are usually trapped in the gaps from solution at room temperature. For scanning tunneling microscopy measurements the molecules are evaporated on clean substrates at ultra-high vacuum.



In this talk I will focus on planar device geometries and discuss the different conduction mechanisms [1] illustrated by recent experimental work. In experiments often the two-terminal break-junction technique is employed, which allows for the investigation of different contact geometries in a convenient way. From these measurements we now largely understand how vibrational modes, contact configurations, the length dependence, and the conjugation of a molecule influence its resistance. In these two-terminal junctions, transport at low bias is determined by an off-resonance tunnelling process and the nano-objects behave as semiconductors –the level position with respect to the Fermi energy of the metallic leads establishes their resistance. Three-terminal devices which incorporate a gate electrode can be used to control the electronic levels independently from the bias voltage such that resonant tunnelling and different redox states become accessible. Coulomb blockade is generally observed; the addition energy is usually larger than $k_B T$ at room temperature. Finer details such as Kondo correlations and excited states can only be observed at cryogenic temperatures and here detailed spectroscopic information can be obtained from the measurements, including the energies from either electronic, vibrational or spin excitations of the object.

Work supported by FOM and the European Union Seventh Framework Programme (FP7/2007-2013) under agreement no. 270369 (ELFOS).

References:

[1] *J.M. Thijssen and H.S.J. van der Zant, Phys. stat. sol. (b)* ***245*** *(2008) 1455-1470*

ST-5

Spin Crossover in Transition Metal Complexes

Michael Shatruk

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Spin crossover is a special case of magnetic bistability observed in certain complexes of d^4-d^7 transition metals. The bistability emerges from the possibility to stabilize two distinct magnetic by changing temperature, applying pressure, or by photoexcitation. The phenomenon relies on the property of a single metal ion, but intermolecular interactions (cooperativity) are of great importance for defining the abruptness and extent of the spin transition. The first part of this tutorial will be devoted to a review of spin crossover in a variety of transition metal complexes, while the second part will focus on approaches to build in higher cooperativity and achieve more abrupt spin transitions