Kevin van Hoogdalem **Journal Club** 29/05/2012

Matthias Menzel, Yuriy Mokrousov, Robert Wieser, Jessica E. Bickel, Elena Vedmedenko, Stefan Blügel, Stefan Heinze, Kirsten von Bergmann, André Kubetzka, and Roland Wiesendanger

Information Transfer by Vector Spin Chirality in Finite Magnetic Chains

Phys. Rev. Lett. ***108****, 197204 (2012)*

Vector spin chirality is one of the fundamental characteristics of complex magnets. For a one-dimensional spin-spiral state it can be interpreted as the handedness, or rotational sense of the spiral. Here, using spin-polarized scanning tunneling microscopy, we demonstrate the occurrence of an atomic-scale spin spiral in finite individual bi-atomic Fe chains on the (5×1)-Ir(001) surface. We show that the broken inversion symmetry at the surface promotes one direction of the vector spin chirality, leading to a unique rotational sense of the spiral in all chains. Correspondingly, changes in the spin direction of one chain end can be probed tens of nanometers away, suggesting a new way of transmitting information about the state of magnetic objects on the nanoscale.

Syarif Riyadi, Baomin Zhang, Robert A. de Groot, Antonio Caretta, Paul H. M. van Loosdrecht, Thomas T. M. Palstra, and Graeme R. Blake

Antiferromagnetic *S*=1/2 Spin Chain Driven by *p*-Orbital Ordering in CsO2

Phys. Rev. Lett. ***108****, 217206 (2012)*

We demonstrate, using a combination of experiment and density functional theory, that orbital ordering drives the formation of a one-dimensional (1D) *S*=1/2 antiferromagnetic spin chain in the 3D rocksalt structure of cesium superoxide (CsO2). The magnetic superoxide anion (O2-) exhibits degeneracy of its 2*p*-derived molecular orbitals, which is lifted by a structural distortion on cooling. A spin chain is then formed by zigzag ordering of the half-filled superoxide orbitals, promoting a superexchange pathway mediated by the *pz* orbitals of Cs+ along only one crystal direction. This scenario is analogous to the 3*d*-orbital-driven spin chain found in the perovskite KCuF3 and is the first example of an inorganic quantum spin system with unpaired *p* electrons.

P. San-Jose, J. González, and F. Guinea

Non-Abelian Gauge Potentials in Graphene Bilayers

Phys. Rev. Lett. 108, 216802 (2012)

We study the effect of spatial modulations in the interlayer hopping of graphene bilayers, such as those that arise upon shearing or twisting. We show that their single-particle physics, characterized by charge accumulation and recurrent formation of zero-energy bands as the pattern period*L* increases, is governed by a non-Abelian gauge potential arising in the low-energy electronic theory due to the coupling between layers. We show that such gauge-type couplings give rise to a potential that, for certain discrete values of *L*, spatially confines states at zero energy in particular regions of the moiré patterns. We also draw the connection between the recurrence of the flat zero-energy bands and the non-Abelian character of the potential.

Jiang Xiao and Gerrit E. W. Bauer

Spin-Wave Excitation in Magnetic Insulators by Spin-Transfer Torque

Phys. Rev. Lett. ***108****, 217204 (2012)*

We study the excitation of spin waves in magnetic insulators by the current-induced spin-transfer torque. We predict preferential excitation of surface spin waves induced by an easy-axis surface anisotropy with critical current inversely proportional to the penetration depth and surface anisotropy. The surface modes strongly reduce the critical current and enhance the excitation power of the current-induced magnetization dynamics.

Xiao-Hui Bao, Andreas Reingruber, Peter Dietrich, Jun Rui, Alexander Dück, Thorsten Strassel, Li Li, Nai-Le Liu, Bo Zhao, and Jian-Wei Pan

Efficient and long-lived quantum memory with cold atoms inside a ring cavity

Nature Physics (2012), doi:10.1038/nphys2324, published online: 20 May 2012

Quantum memories are regarded as one of the fundamental building blocks of linear-optical quantum computation and long-distance quantum communication. A long-standing goal to realize scalable quantum information processing is to build a long-lived and efficient quantum memory. There have been significant efforts distributed towards this goal. However, either efficient but short-lived or long-lived but inefficient quantum memories have been demonstrated so far. Here we report a high-performance quantum memory in which long lifetime and high retrieval efficiency meet for the first time. By placing a ring cavity around an atomic ensemble, employing a pair of clock states, creating a long-wavelength spin wave and arranging the set-up in the gravitational direction, we realize a quantum memory with an intrinsic spin wave to photon conversion efficiency of 73(2)% together with a storage lifetime of 3.2(1) ms. This realization provides an essential tool towards scalable linear-optical quantum information processing.

V. Mourik, K. Zuo, S. M. Frolov, S. R. Plissard, E. P. A. M. Bakkers, and L. P. Kouwenhoven
Signatures of Majorana Fermions in Hybrid Superconductor-Semiconductor Nanowire Devices
*Science **336**, 1003 (2012)*
Theoretically predicted particles that double as their own antiparticles emerge in a superconductor-coupled indium antimonide nanowire.

In Chung, Byunghong Lee, Jiaqing He, Robert P. H. Chang, and Mercouri G. Kanatzidis
All-solid-state dye-sensitized solar cells with high efficiency
Nature **485**, 486 (2012)
A solution-processable inorganic semiconductor is reported that can replace the liquid electrolyte of dye-sensitized solar cells, yielding all-solid-state solar cells with impressive energy conversion efficiencies.

H. Hettmansperger, F. Duerr, J.B. Oostinga, C. Gould, B. Trauzettel, L.W. Molenkamp
Quantum Hall effect in narrow graphene ribbons
arXiv:1205.5144v1 [cond-mat.mes-hall]
The edge states in the integer quantum Hall effect are known to be significantly affected by electrostatic interactions leading to the formation of compressible and incompressible strips at the boundaries of Hall bars. We show here, in a combined experimental and theoretical analysis, that this common wisdom no longer holds for the quantum Hall effect in narrow graphene ribbons. In our graphene Hall bar, which is only 60 nm wide, we observe the quantum Hall effect up to Landau level index k=2 and show within a zero free-parameter model that the spatial extend of the compressible and incompressible strips is of similar magnitude as the magnetic length. We conclude that in narrow graphene ribbons the single-particle picture is a more appropriate description of the quantum Hall effect, and that electrostatic effects are of minor importance.

Filippo Troiani, Dimitrije Stepanenko, Daniel Loss
Hyperfine-induced decoherence in triangular spin-cluster qubits
arXiv:1205.5629v1 [cond-mat.mes-hall]
We investigate hyperfine-induced decoherence in a triangular spin-cluster for different qubit encodings. Electrically controllable eigenstates of spin chirality (C_z) show decoherence times that approach milliseconds, two orders of magnitude longer than those estimated for the eigenstates of the total spin projection (S_z) and of the partial spin sum (S_{12}). The robustness of chirality is due to its decoupling from both the total- and individual-spin components in the cluster. This results in a suppression of the effective interaction between C_z and the nuclear spin bath.

Franziska Maier and Daniel Loss
Effect of strain on hyperfine-induced hole-spin decoherence in quantum dots
*Phys. Rev. B **85**, 195323 (2012)*
We theoretically consider the effect of strain on the spin dynamics of a single heavy hole (HH) confined to a self-assembled quantum dot and interacting with the surrounding nuclei via hyperfine interaction. Confinement and strain hybridize the HH states, which show an exponential decay for a narrowed nuclear spin bath. For different strain configurations within the dot, the dependence of the spin decoherence time $T2$ on external parameters is shifted and the nonmonotonic dependence of the peak is altered. Application of external strain yields considerable shifts in the dependence of $T2$ on external parameters. We find that external strain affects mostly the effective hyperfine coupling strength of the conduction band (CB), indicating that the CB admixture of the hybridized HH states plays a crucial role in the sensitivity of $T2$ on strain.