Magnetization of the Metallic Surface States in Topological Insulators
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arXiv:1411.5973 [cond-mat.mes-hall]
(Accepted for publication in J. Phys.: Condens. Matter)

We calculate the magnetization of the helical metallic surface states of a topological insulator. We account for the presence of a small sub-dominant Schrödinger piece in the Hamiltonian in addition to the dominant Dirac contribution. This breaks particle-hole symmetry. The cross-section of the upper Dirac cone narrows while that of the lower cone broadens. The sawtooth pattern seen in the magnetization of the pure Dirac limit as a function of chemical potential (μ) is shifted; but, the quantization of the Hall plateaus remains half integral. This is verified by taking the derivative of the magnetization with respect to μ. We compare our results with those when the non-relativistic piece dominates over the relativistic contribution and the quantization is integral. Analytic results for the magnetic oscillations are obtained where we include a first order correction in the ratio of non-relativistic to relativistic magnetic energy scales. Our fully quantum mechanical derivations confirm the expectation of semiclassical theory except for a small correction to the expected phase. There is a change in the overall amplitude of the magnetic oscillations. The Dingle and temperature factors are modified.

Quantum manipulation of two-electron spin states in metastable double quantum dots
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arXiv:1411.7065 [cond-mat.mes-hall]

We studied experimentally the dynamics of the exchange interaction between two antiparallel electron spins in a so-called metastable double quantum dot where coupling to the electron reservoirs can be ignored. We demonstrate that the level of control of such a double dot is higher than in conventional double dots. In particular, it allows to couple coherently two electron spins in an efficient manner following a scheme initially proposed by Loss and DiVincenzo. The present study demonstrates that metastable quantum dots are a possible route to increase the number of coherently coupled quantum dots.

Quantum factorization of 44929 with only 4 qubits
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arXiv:1411.6758 [quant-ph]

The largest number factored on a quantum device reported until now was 143. That quantum computation, which used only 4 qubits, actually also factored much larger numbers such as 3599, 13081, and 44929, without the awareness of the authors of that work. Furthermore, unlike the implementations of Shor's algorithm performed thus far, these 4-qubit factorizations do not need to use prior knowledge of the answer. However, because they only use 4 qubits, these factorizations can also be performed trivially on classical computers. We discover a class of numbers for which the power of quantum information actually comes into play. We then demonstrate a 3-qubit factorization of 175, which would be the first quantum factorization of a triprime.

Towards high mobility InSb nanowire devices
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arXiv:1411.7285 [cond-mat.mes-hall]

We study the low-temperature electron mobility of InSb nanowires. We extract the mobility at 4.2 Kelvin by means of field effect transport measurements using a model consisting of a nanowire-transistor with contact resistances. This model enables an accurate extraction of device parameters, thereby allowing for a systematic study of the nanowire mobility. We identify factors affecting the mobility, and after optimization

obtain a field effect mobility of ~2.5 x 10^4 cm^2/Vs. We further demonstrate the reproducibility of these mobility values which are among the highest reported for nanowires. Our investigations indicate that the mobility is currently limited by adsorption of molecules to the nanowire surface and/or the substrate.

Spin ordering in RKKY nanowires: Controllable phases in ^{13}C nanotubes

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Phys. Rev. B **90**, 195447 (2014)

Detailed study of nuclear spin order in semiconducting ^{13}C nanotubes reveals subtle interplay of the chemical potential, length, diameter, and chirality, resulting in the complex four-dimensional phase diagram of the helical ground states. Increase of the chemical potential causes abrupt transitions between different helical spin orderings of three regimes which are interpolated by a smooth change of helical angle within each regime: in the middle one the helimagnet is a deviation from the commensurate order and fully characterizes the geometry of the nanotube, while outside it the ground state is an incommensurate helical deviation from the ferromagnet. This behavior of the ^{13}C nanotubes manifests the long-range of the RKKY interaction and quasi-one-dimensional geometry, thus being universal for all RKKY interaction governed nanowires. Short enough nanotubes are ferromagnetic; the critical length when frustration arises decreases with the chemical potential but increases with diameter and chiral angle. The results, verified numerically, show that with nanotubes of the different but realistic lengths, various scenarios of the helical order response to the gate voltage can be achieved.

Exchange interaction and tunneling-induced transparency in coupled quantum dots

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Phys. Rev. B **90**, 205311 (2014)

We investigate the optical response of quantum dot molecules coherently driven by polarized laser light. Our description includes the splitting in excitonic levels caused by isotropic and anisotropic exchange interactions. We consider interdot transitions mediated by hole tunneling between states with the same total angular momentum and between bright and dark exciton states as allowed by spin-flip hopping between the dots in the molecule. Using realistic experimental parameters we demonstrate that the excitonic states coupled by tunneling exhibit a rich and controllable optical response. We show that through the appropriate control of an external electric field and light polarization, the tunneling coupling establishes an efficient destructive quantum interference path that creates a transparency window in the absorption spectra whenever states of appropriate symmetry are mixed by the carrier tunneling. We explore the relevant parameter space that allows probing this phenomenon in experiments. Controlled variation in applied field and laser detuning would allow the optical characterization of spin-preserving and spin-flip hopping amplitudes in such systems by measuring the width of the tunneling-induced transparency windows.

Coherent Precession of an Individual 5/2 Spin

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Phys. Rev. Lett. **113**, 227202 (2014)

We present direct observation of a coherent spin precession of an individual Mn^{2+} ion, having both electronic and nuclear spins equal to 5/2, embedded in a CdTe quantum dot and placed in a magnetic field. The spin state evolution is probed in a time-resolved pump-probe measurement of absorption of the single dot. The experiment reveals subtle details of the large-spin coherent dynamics, such as nonsinusoidal evolution of states occupation, and beatings caused by the strain-induced differences in energy levels separation. Sensitivity of the large-spin impurity on the crystal strain opens the possibility of using it as a local strain probe.

Physics of Beer Tapping

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Phys. Rev. Lett. **113**, 214501 (2014)