**Journal Club-30-08-2011-Suhas Gangadharaiah**

**Magneto-Optical Faraday and Kerr Effects in Topological Insulator Films and in Other Layered Quantized Hall Systems**

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We present a theory of the magneto-optical Faraday and Kerr effects of topological insulator (TI) films. For film thicknesses short compared to wavelength, we find that the low-frequency Faraday effect in ideal systems is quantized at integer multiples of the fine structure constant, and that the Kerr effect exhibits a giant $\pi/2$ rotation for either normal or oblique incidence. For thick films that contain an integer number of half wavelengths, we find that the Faraday and Kerr effects are both quantized at integer multiples of the fine structure constant. For TI films with bulk parallel conduction, we obtain a criterion for the observability of surface-dominated magneto-optical effects. For thin samples supported by a substrate, we find that the universal Faraday and Kerr effects are present when the substrate is thin compared to the optical wavelength or when the frequency matches a thick-substrate cavity resonance. Our theory applies equally well to any system with two conducting layers that exhibit quantum Hall effects.

**Conductance fluctuations in graphene devices with superconducting contacts in different charge density regimes**

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Conductions fluctuations (CF) are studied in single layer graphene devices with superconducting source and drain contacts made from aluminium. The CF are found to be enhanced by superconductivity by a factor of 1.4 to 2. This (near) doubling of the CF indicates that the phase coherence length is l\_phi >= L/2. As compared to previous work, we find a relatively weak dependence of the CF on the gate voltage, and hence on the carrier density. We also demonstrate that whether the CF are larger or smaller at the charge neutrality point can be strongly dependent on the series resistance R\_C, which needs to be subtracted.

**Single-Particle Tunneling in Doped Graphene-Insulator-Graphene Junctions**

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The characteristics of tunnel junctions formed between n- and p-doped graphene are investigated theoretically. The single-particle tunnel current that flows between the two-dimensional electronic states of the graphene (2D-2D tunneling) is evaluated. At a voltage bias such that the Dirac points of the two electrodes are aligned, a large resonant current peak is produced. The magnitude and width of this peak is computed, and its use for devices is discussed. The influence of both rotational alignment of the graphene electrodes and structural perfection of the graphene is discussed.

**Quantum Anomalous Hall Effect in Magnetic Topological Insulator GdBiTe3**

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The quantum anomalous Hall (QAH) state is a two-dimensional bulk insulator with a non-zero Chern number in absence of external magnetic fields. Protected gapless chiral edge states enable dissipationless current transport in electronic devices. Doping topological insulators with random magnetic impurities could realize the QAH state, but magnetic order is difficult to establish experimentally in the bulk insulating limit. Here we predict that the single quintuple layer of GdBiTe3 film could be a stoichiometric QAH insulator based on ab-initio calculations, which explicitly demonstrate ferromagnetic order and chiral edge states inside the bulk gap. We further investigate the topological quantum phase transition by tuning the lattice constant and interactions. A simple low-energy effective model is presented to capture the salient physical feature of this topological material.

**Analytical solutions to zeroth-order dispersion relations of a cylindrical metallic nanowire**

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Zeroth-order complex dispersion relations of a cylindrical metallic nanowire have been solved out analytically with approximate methods. The analytical solutions are valid for the sections of the dispersion relations whose frequencies are close to the Surface Plasmon frequency. The back bending of the Surface Plasmon-Polaritons(SPPs) can be well described by the analytical solutions, confirming that the back bending is originated from the metal Ohmic loss. The utility of the back bending point in the dispersion relation for the measurement of the metallic Ohimc loss has also been suggested.

**Exactly soluble models for fractional topological insulators in 2 and 3 dimensions**

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We construct exactly soluble lattice models for fractionalized, time reversal invariant electronic insulators in 2 and 3 dimensions. The low energy physics of these models is exactly equivalent to a non-interacting topological insulator built out of fractionally charged fermionic quasiparticles. We show that some of our models have protected edge modes (in 2D) and surface modes (in 3D), and are thus fractionalized analogues of topological insulators. We also find that some of the 2D models do not have protected edge modes -- that is, the edge modes can be gapped out by appropriate time reversal invariant, charge conserving perturbations. (A similar state of affairs may also exist in 3D). We show that all of our models are topologically ordered, exhibiting fractional statistics as well as ground state degeneracy on a torus. In the 3D case, we find that the models exhibit a fractional magnetoelectric effect.

**Current-Conserving Aharonov-Bohm Interferometry with Arbitrary Spin Interactions** [Minchul Lee](http://arxiv.org/find/cond-mat/1/au:+Lee_M/0/1/0/all/0/1), [Dimitrije Stepanenko](http://arxiv.org/find/cond-mat/1/au:+Stepanenko_D/0/1/0/all/0/1) [**arXiv:1108.4775**](http://arxiv.org/abs/1108.4775) We propose a general scattering matrix formalism that guarantees the charge conservation at junctions between conducting arms with arbitrary spin interactions. By using our formalism, we find that the spin-flip scattering can happen even at nonmagnetic junctions if the spin eigenstates in arms are not orthogonal. We apply our formalism to the Aharonov-Bohm interferometer consisting of $n$-type semiconductor ring with both the Rashba spin-orbit coupling and the Zeeman splitting. We discuss the characteristics of the interferometer as conditional/unconditional spin switch in the weak/strong-coupling limit, respectively.

**Conductance fluctuations in chaotic systems with tunnel barriers**

[Daniel Waltner](http://arxiv.org/find/cond-mat/1/au:+Waltner_D/0/1/0/all/0/1), [Jack Kuipers](http://arxiv.org/find/cond-mat/1/au:+Kuipers_J/0/1/0/all/0/1), [Philippe Jacquod](http://arxiv.org/find/cond-mat/1/au:+Jacquod_P/0/1/0/all/0/1), [Klaus Richter](http://arxiv.org/find/cond-mat/1/au:+Richter_K/0/1/0/all/0/1) [**arXiv:1108.5091**](http://arxiv.org/abs/1108.5091)

Quantum effects are expected to disappear in the short-wavelength, semiclassical limit. As a matter of fact, recent investigations of transport through quantum chaotic systems have demonstrated the exponential suppression of the weak localization corrections to the conductance and of the Fano factor for shot-noise when the Ehrenfest time exceeds the electronic dwell time. On the other hand, conductance fluctuations, an effect of quantum coherence, retain their universal value in the limit of the ratio of Ehrenfest time over dwell time to infinity, when the system is ideally coupled to external leads. Motivated by this intriguing result we investigate conductance fluctuations through quantum chaotic cavities coupled to external leads via (tunnel) barriers of arbitrary transparency. Using the trajectory-based semiclassical theory of transport, we find a linear Ehrenfest time-dependence of the conductance variance showing a nonmonotonous, sinusoidal behavior as a function of the transperancy. Most notably, we find an increase of the conductance fluctuations with the Ehrenfest time, above their universal value, for the transparency less than 0.5. These results, confirmed by numerical simulations, show that, contrarily to the common wisdom, effects of quantum coherence may increase in the semiclassical limit, under special circumstances.

**Asymmetric Double Quantum Wells with Smoothed Interfaces**

[Vladimir Gavryushin](http://arxiv.org/find/cond-mat/1/au:+Gavryushin_V/0/1/0/all/0/1) [**arXiv:1108.5374**](http://arxiv.org/abs/1108.5374)

We have derived and analyzed the wavefunctions and energy states for an asymmetric double quantum wells, broadened due to static interface disorder effects, within well known discreet variable representation approach for solving the one-dimensional Schrodinger equation. The main advantage of this approach is that it yields the energy eigenvalues and the eigenvectors in semiconductor nanostructures of different shapes as well as the strengths of the optical transitions between them. We have found that interface broadening effects change and shift energy levels to higher energies, but the resonant conditions near an energy coupling regions do not strongly distorted. A quantum-mechanical calculations based on the convolution method (smoothing procedure) of the influence of disorder on the motion of free particles in nanostructures is presented.

**Direct observation of correlation time of dynamic nuclear polarization in single quantum dots**

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The spin interaction between an electron and nuclei was investigated optically in a single self-assembled InAlAs quantum dot (QD). In spin dynamics, the correlation time of the coupled electron-nuclear spin system and the electron spin relaxation time play a crucial role. We examined on a positively charged exciton in a QD to evaluate these key time constants directly via the temporal evolution measurements of the Overhauser shift and the degree of circular polarization. In addition, the validity of our used spin dynamics model was discussed in the context of the experimentally obtained key parameters.