Formation of Strain-Induced Quantum Dots in Gated Semiconductor Nanostructures
Ted Thorbeck, Neil M. Zimmerman, arXiv:1409.3549
Elastic strain changes the energies of the conduction band in a semiconductor, which will affect transport through a semiconductor nanostructure. We show that the typical strains in a semiconductor nanostructure from metal gates are large enough to create strain-induced quantum dots (QDs). We simulate a commonly used QD device architecture, metal gates on bulk silicon, and show the formation of strain-induced QDs. The strain-induced QD can be eliminated by replacing the metal gates with poly-silicon gates. Thus strain can be as important as electrostatics to QD device operation operation.

The formation of nonequilibrium steady states in interacting double quantum dots: When coherences dominate the charge distribution
R. Hrtle, A. J. Millis, arXiv:1409.3504
We theoretically investigate the full time evolution of a nonequilibrium double quantum dot structure from initial conditions corresponding to product states (no entanglement between dot and lead) to a nonequilibrium steady state. The structure is described by a two-level spinless Anderson model where the levels are coupled to two leads held at different chemical potentials. The problem is solved by a numerically exact hierarchical master equation technique and the results are compared to approximate results obtained from Born-Markov theory. The methods allow us to study the time evolution up to times of order 104 of the bare hybridization time, enabling eludication of the role of coherent charge oscillations and an interaction-induced renormalization of energy levels. We find that when the system carries a single electron on average the formation of the steady state is strongly influenced by the coherence between the dots. The latter can be sizeable and indeed larger in the presence of a bias voltage than it is in equilibrium. Moreover, the interdot coherence is shown to lead to a pronounced difference in the population of the dots.

Signature of snaking states in the conductance of core-shell nanowires
Tomas Orn Rosdahl, Andrei Manolescu, Vidar Gudmundsson, arXiv:1409.3429
We model a core-shell nanowire (CSN) by a cylindrical surface of finite length. A uniform magnetic field perpendicular to the axis of the cylinder forms electron states along the lines of zero radial field projection, which can classically be described as snaking states. In a strong field, these states converge pairwise to quasidegenerate levels, which are situated at the bottom of the energy spectrum. We calculate the conductance of the CSN by coupling it to leads, and predict that the snaking states govern transport at low chemical potential, forming isolated peaks, each of which may be split in two by applying a transverse electric field. If the contacts with the leads do not completely surround the CSN, as is usually the case in experiments, the amplitude of the snaking peaks changes when the magnetic field is rotated, determined by the overlap of the contacts with the snaking states.

Twisted Gauge Theory Model of Topological Phases in Three Dimensions
Yidun Wan, Juven Wang, Huan He, arXiv:1409.3216
We propose an exactly solvable lattice Hamiltonian model of topological phases in 3+1 dimensions, based on a generic finite group G and a 4-cocycle ω over G. We show that our model has topologically protected degenerate ground states and obtain the formula of its ground state degeneracy on the 3-torus. In particular, the ground state spectrum implies the existence of purely three-dimensional looplike quasi-excitations specified by two nontrivial flux indices and one charge index. We also construct other nontrivial topological observables of the model, namely the three-dimensional modular S and T matrices of the ground states, which yield a set of topological quantum numbers classified by ω and quantities derived from ω. Our model fulfills a Hamiltonian extension of the 3+1-dimensional Dijkgraaf-Witten topological gauge theory with a gauge group G. This work is presented to be accessible for a wide range of physicists and mathematicians.

Anyon braiding in semi-analytical fractional quantum Hall lattice models *A. E. B. Nielsen, arXiv:1409.3073* It has been demonstrated numerically, mainly by considering ground state properties, that fractional quantum Hall physics can appear in lattice systems, but it is very difficult to study the anyons directly. Here, I propose to solve this problem by using conformal field theory to build semi-analytical fractional quantum Hall lattice models having anyons in their ground states, and I carry out the construction explicitly for the family of bosonic and fermionic Laughlin states. This enables me to show directly that the braiding properties of the anyons are those expected from analytical continuation of the wave functions and to compute properties such as internal structure, size, and charge of the anyons with simple Monte Carlo simulations. The models can also be used to study how the anyons behave when they approach or even pass through the edge of the sample. Finally, I compute the effective magnetic field seen by the anyons, which varies periodically due to the presence of the lattice.

Orbital hyperfine interaction and qubit de-

phasing in carbon nanotube quantum dots
Gbor Csiszr, Andrs Plyi, arXiv:1409.2756
Hyperfine interaction (HF) is of key importance for the functionality of solid-state quantum information processing, as it affects qubit coherence and enables nuclear-spin quantum memories. In this work, we complete the theory of the basic hyperfine interaction mechanisms (Fermi contact, dipolar, orbital) in carbon nanotube quantum dots by providing a theoretical description of the orbital HF. We find that orbital HF induces an interaction between the nuclear spins of the nanotube lattice and the valley degree of freedom of the electrons confined in the quantum dot. We show that the resulting nuclear-spin–electron-valley interaction (i) is approximately of Ising type, (ii) is essentially local, in the sense that a radius- and dot-length-independent atomic interaction strength can be defined, and (iii) has an atomic interaction strength that is comparable to the combined strength of Fermi contact and dipolar interactions. We argue that orbital HF provides a new decoherence mechanism for single-electron valley qubits and spin-valley qubits in a range of multi-valley materials. We explicitly evaluate the corresponding inhomogeneous dephasing time T_2^* for a nanotube-based valley qubit.

Fourier Magnetic Imaging with Nanoscale Resolution and Compressed Sensing Speed-up using Electronic Spins in Diamond
K. Arai, C. Belthangady, H. Zhang, N. Bar-Gill, S. J. DeVience, P. Cappellaro, A. Yacoby, R. L. Walsworth, arXiv:1409.2749
Optically-detected magnetic resonance using Nitrogen Vacancy (NV) color centres in diamond is a leading modality for nanoscale magnetic field imaging, as it provides single electron spin sensitivity, three-dimensional resolution better than 1 nm, and applicability to a wide range of physical and biological samples under ambient conditions. To date, however, NV-diamond magnetic imaging has been performed using real space techniques, which are either limited by optical diffraction to 250 nm resolution or require slow, point-by-point scanning for nanoscale resolution, e.g., using an atomic force microscope, magnetic tip, or super-resolution optical imaging. Here we introduce an alternative technique of Fourier magnetic imaging using NV-diamond. In analogy with conventional magnetic resonance imaging (MRI), we employ pulsed magnetic field gradients to phase-encode spatial information on NV electronic spins in wavenumber or k-space followed by a fast Fourier transform to yield real-space images with nanoscale resolution, wide field-of-view (FOV), and compressed sensing speed-up.

Anisotropy of spin-orbit induced electron spin relaxation in [001] and [111] grown GaAs quantum dots
C. Segarra, J. Planelles, J. I. Climente, F. Rajadell, arXiv:1409.2392
We report a systematic study of the spin relaxation anisotropy between single electron Zeeman sublevels in cuboidal GaAs quantum dots (QDs). The QDs are subject to an in-plane magnetic field. As the field orientation varies, the relaxation rate oscillates periodically, showing "magic" angles where the relaxation rate is suppressed by several orders of magnitude. This behavior is found in QDs with different shapes, heights, crystallographic orientations and external fields. The origin of these angles can be traced back to the symmetries of the spin admixing terms of the Hamiltonian. In [001] grown QDs, the suppression angles are different for Rashba and Dresselhaus spin-orbit terms. By contrast, in [111] grown QDs they are the same, which should facilitate a thorough suppression of spin-orbit induced relaxation. Our results evidence that cubic Dresselhaus terms play a critical role in determining the spin relaxation anisotropy even in quasi-2D QDs.

Strain induced edge magnetism at zigzag edge in graphene quantum dot
Shuai Cheng, Jinming Yu, Tianxing Ma, N. M. R. Peres, arXiv:1409.2341
We study the temperature dependent magnetic susceptibility of a strained graphene quantum dot by using the determinant quantum Monte Carlo method. Within the Hubbard model on a honeycomb lattice, our unbiased numerical results show that a relative small interaction U may lead to a edge ferromagnetic like behavior in the strained graphene quantum dot, and a possible room temperature transition is suggested. Around half filling, the ferromagnetic fluctuations at the zigzag edge is strengthened both markedly by the on-site Coulomb interaction and the strain, especially in low temperature region. The resultant strongly enhanced ferromagnetic like behavior may be important for the development of many applications.