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Spin backflow and ac Voltage Generation by Spin Pumping and the Inverse Spin Hall Effect

Phys. Rev. Lett. ***110****, 217602 (2013)*

The spin current pumped by a precessing ferromagnet into an adjacent normal metal has a constant polarization component parallel to the precession axis and a rotating one normal to the magnetization. The former is now routinely detected as a dc voltage induced by the inverse spin Hall effect (ISHE). Here we compute ac ISHE voltages much larger than the dc signals for various material combinations and discuss optimal conditions to observe the effect. The backflow of spin is shown to be essential to distill parameters from measured ISHE voltages for both dc and ac configurations.

J. D. Thompson, T. G. Tiecke, N. P. de Leon, J. Feist, A. V. Akimov, M. Gullans, A. S. Zibrov, V. Vuletić, M. D. Lukin

Coupling a Single Trapped Atom to a Nanoscale Optical Cavity

Science ***340****, 1202 (2013)*

Hybrid quantum devices, in which dissimilar quantum systems are combined in order to attain qualities not available with either system alone, may enable far-reaching control in quantum measurement, sensing, and information processing. A paradigmatic example is trapped ultracold atoms, which offer excellent quantum coherent properties, coupled to nanoscale solid-state systems, which allow for strong interactions. We demonstrate a deterministic interface between a single trapped rubidium atom and a nanoscale photonic crystal cavity. Precise control over the atom's position allows us to probe the cavity near-field with a resolution below the diffraction limit and to observe large atom-photon coupling. This approach may enable the realization of integrated, strongly coupled quantum nano-optical circuits.

C. R. Dean, L. Wang, P. Maher, C. Forsythe, F. Ghahari, Y. Gao, J. Katoch, M. Ishigami, P. Moon, M. Koshino, T. Taniguchi, K. Watanabe, K. L. Shepard, J. Hone, and P. Kim

Hofstadter's butterfly and the fractal quantum Hall effect in moiré superlattices

Nature 497, 598 (2013)

Electrons moving through a spatially periodic lattice potential develop a quantized energy spectrum consisting of discrete Bloch bands. In two dimensions, electrons moving through a magnetic field also develop a quantized energy spectrum, consisting of highly degenerate Landau energy levels. When subject to both a magnetic field and a periodic electrostatic potential, two-dimensional systems of electrons exhibit a self-similar recursive energy spectrum. Known as Hofstadter's butterfly, this complex spectrum results from an interplay between the characteristic lengths associated with the two quantizing fields, and is one of the first quantum fractals discovered in physics. In the decades since its prediction, experimental attempts to study this effect have been limited by difficulties in reconciling the two length scales. Here we demonstrate that moiré superlattices arising in bilayer graphene coupled to hexagonal boron nitride provide a periodic modulation with ideal length scales of the order of ten nanometres, enabling unprecedented experimental access to the fractal spectrum. We confirm that quantum Hall features associated with the fractal gaps are described by two integer topological quantum numbers, and report evidence of their recursive structure.

X.-D. Cai, C. Weedbrook, Z.-E. Su, M.-C. Chen, Mile Gu, M.-J. Zhu, Li Li, Nai-Le Liu, Chao-Yang Lu, and Jian-Wei Pan

Experimental Quantum Computing to Solve Systems of Linear Equations

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Solving linear systems of equations is ubiquitous in all areas of science and engineering. With rapidly growing data sets, such a task can be intractable for classical computers, as the best known classical algorithms require a time proportional to the number of variables *N*. A recently proposed quantum algorithm shows that quantum computers could solve linear systems in a time scale of order log(*N*), giving an exponential speedup over classical computers. Here we realize the simplest instance of this algorithm, solving 2×2 linear equations for various input vectors on a quantum computer. We use four quantum bits and four controlled logic gates to implement every subroutine required, demonstrating the working principle of this algorithm.

Andreas Kehlberger, René Röser, Gerhard Jakob, Ulrike Ritzmann, Denise Hinzke, Ulrich Nowak, Mehmet C. Onbasli, Dong Hun Kim, Caroline A. Ross, Matthias B. Jungfleisch, Burkard Hillebrands, Mathias Kläui
Determination of the origin of the spin Seebeck effect - bulk vs. interface effects
arXiv:1306.0784 [cond-mat.mtrl-sci]
The observation of the spin Seebeck effect in insulators has meant a breakthrough for spin caloritronics due to the unique ability to generate pure spin currents by thermal excitations in insulating systems without moving charge carriers. Since the recent first observation, the underlying mechanism and the origin of the observed signals have been discussed highly controversially. Here we present a characteristic dependence of the longitudinal spin Seebeck effect amplitude on the thickness of the insulating ferromagnet (YIG). Our measurements show that the observed behavior cannot be explained by any effects originating from the interface, such as magnetic proximity effects in the spin detector (Pt). Comparison to theoretical calculations of thermal magnonic spin currents yields qualitative agreement for the thickness dependence resulting from the finite effective magnon propagation length so that the origin of the effect can be traced to genuine bulk magnonic spin currents ruling out parasitic interface effects.

A. Khaetskii, V. N. Golovach, X. Hu, I. Žutić
A phonon laser utilizing quantum-dot spin states
arXiv:1306.1786 [cond-mat.mes-hall]
We propose a nano-scale realization of a phonon laser utilizing phonon-assisted spin flips in quantum dots to amplify sound. Owing to a long spin relaxation time, the device can be operated in a strong pumping regime, in which the population inversion is close to its maximal value allowed under Fermi statistics. In this regime, the threshold for stimulated emission is unaffected by spontaneous spin flips. Considering a nanowire with quantum dots defined along its length, we show that a further improvement arises from confining the phonons to one dimension, and thus reducing the number of phonon modes available for spontaneous emission. Our work calls for the development of nanowire-based, high-finesse phonon resonators.

C. P. Scheller, T.-M. Liu, G. Barak, A. Yacoby, L. N. Pfeiffer, K. W. West, D. M. Zumbühl
Evidence for Helical Nuclear Spin Order in GaAs Quantum Wires
arXiv:1306.1940 [cond-mat.mes-hall]
We present transport measurements of cleaved edge overgrowth GaAs quantum wires. The conductance of the first mode reaches 2 e^2/h at high temperatures T > 10 K, as expected. As T is lowered, the conductance is gradually reduced to 1 e^2/h, becoming T-independent at T < 0.1 K, while the device cools far below 0.1 K. This behavior is seen in several wires, is independent of density, and not altered by moderate magnetic fields B. The conductance reduction by a factor of two suggests lifting of the electron spin degeneracy in absence of B. Our results are consistent with theoretical predictions for helical nuclear magnetism in the Luttinger liquid regime.

Samuel Aldana, Christoph Bruder, and Andreas Nunnenkamp
On the equivalence between an optomechanical system and a Kerr medium
arXiv:1306.0415 [quant-ph]