Full electrical control of the electron spin relaxation in GaAs quantum wells

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The electron spin dynamics in (111)-oriented GaAs/AlGaAs quantum wells is studied by time-resolved photoluminescence spectroscopy. By applying an external electric field of 50 kV/cm a two-order of magnitude increase of the spin relaxation time can be observed reaching values larger than 30 ns; this is a consequence of the electric field tuning of the spin-orbit conduction band splitting which can almost vanish when the Rashba term compensates exactly the Dresselhaus one. The measurements under a transverse magnetic field demonstrate that the electron spin relaxation time for the three space directions can be tuned simultaneously with the applied electric field.

Measurement of the neutrino velocity with the OPERA detector in the CNGS beam

OPERA Collaboration
arXiv:1109.4897v1 [hep-ex]

The OPERA neutrino experiment at the underground Gran Sasso Laboratory has measured the velocity of neutrinos from the CERN CNGS beam over a baseline of about 730 km with much higher accuracy than previous studies conducted with accelerator neutrinos. The measurement is based on high-statistics data taken by OPERA in the years 2009, 2010 and 2011. Dedicated upgrades of the CNGS timing system and of the OPERA detector, as well as a high precision geodesy campaign for the measurement of the neutrino baseline, allowed reaching comparable systematic and statistical accuracies. An early arrival time of CNGS muon neutrinos with respect to the one computed assuming the speed of light in vacuum of (60.7 ± 6.9 (stat.) ± 7.4 (sys.)) ns was measured. This anomaly corresponds to a relative difference of the muon neutrino velocity with respect to the speed of light (v-c)/c = (2.48 ± 0.28 (stat.) ± 0.30 (sys.)) 10^{-5}.

Quantum control of proximal spins using nanoscale magnetic resonance imaging

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Single electron spins have been detected before, but the methods used proved difficult to extend to multi-spin systems. A magnetic resonance imaging technique is now demonstrated that resolves proximal spins in three dimensions with nanometre-scale resolution. In addition to spatial mapping, the approach allows for coherent control of the individual spins.

Leakage-current lineshapes from inelastic cotunneling in the Pauli spin blockade regime

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arXiv:1109.4445v1 [cond-mat.mes-hall]

We find the leakage current through a double quantum dot in the Pauli spin blockade regime accounting for inelastic (spin-flip) cotunneling processes. Taking the energy-dependence of this spin-flip mechanism into account allows for an accurate description of the current as a function of applied magnetic fields, gate voltages, and an inter-dot tunnel coupling. In the presence of an additional local dephasing process or nonuniform magnetic field, we obtain a simple closed-form analytical expression for the leakage current giving the full dependence on an applied magnetic field and energy detuning. This work is important for understanding the nature of leakage, especially in systems where other spin-flip mechanisms (due, e.g., to hyperfine coupling to nuclear spins or spin-orbit coupling) are weak, including silicon and carbon-nanotube or graphene quantum dots.

Experimental high-dimensional two-photon entanglement and violations of generalized Bell inequalities

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Bell's theorem experiments, which test the completeness of quantum mechanics, have a number of loopholes. However, one type—detection loopholes—becomes smaller when the measurement has more possible outcomes. Bell's inequality is now violated in tests with as many as 11 different results.

Signature of Majorana fermions in charge transport in semiconductor nanowires

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We investigate the charge transport in a semiconductor nanowire that is subject to a perpendicular magnetic field and in partial contact with an s-wave superconductor. We find that Majorana fermions, existing at the interface between superconducting and normal sections of the nanowire within certain parameter region, can induce resonant Andreev reflection of electrons at the interface, which yields a zero energy peak in the electrical conductance of the nanowire. The width of the zero energy conductance peak for different experimental parameters is characterized. While the zero energy peak provides a signature for Majorana fermions in one dimensional nanowires, it disappears in a two-dimensional semiconductor thin film with the same experimental setup because of the existence of other edge states in two dimensions. The proposed charge transport experiment may provide a simple and experimentally feasible method for the detection of Majorana fermions in semiconductor nanowires.

In situ tunable g factor for a single electron confined inside an InAs quantum dot

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Tailoring the properties of single spins confined in self-assembled quantum dots (QDs) is critical to the development of new optoelectronic logic devices. However, the range of heterostructure engineering techniques that can be used to control spin properties is severely limited by the requirements of QD self-assembly. We demonstrate a new strategy for rationally engineering the spin properties of single confined electrons or holes by adjusting the composition of the barrier between a stacked pair of InAs QDs coupled by coherent tunneling to form a quantum dot molecule (QDM). We demonstrate this strategy by designing, fabricating, and characterizing a QDM in which the g-factor for a single confined electron can be tuned in situ by over 50% with a minimal change in applied voltage.

Finite-Bias Cooper Pair Splitting

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In a device with a superconductor coupled to two parallel quantum dots (QDs) the electrical tunability of the QD levels can be used to exploit nonclassical current correlations due to the splitting of Cooper pairs. We experimentally investigate the effect of a finite potential difference across one quantum dot on the conductance through the other completely grounded QD in a Cooper pair splitter fabricated on an InAs nanowire. We demonstrate that the nonlocal electrical transport through the device can be tuned by electrical means and that the energy dependence of the effective density of states in the QDs is relevant for the rates of Cooper pair splitting (CPS) and elastic cotunneling. Such experimental tools are necessary to understand and develop CPS-based sources of entangled electrons in solid-state devices.