Physical Review B **85**, 195409 (2012)

Resonant modes in strain-induced graphene superlattices

F. M. D. Pellegrino,[1,2] G. G. N. Angilella,[1,2,3,4] and R. Pucci[1,2]

(1) Dipartimento di Fisica e Astronomia, Universit di Catania, Italy; (2) CNISM, Catania, Italy; (3) Scuola Superiore di Catania, Universit di Catania, Italy; (4) INFN, Catania, Italy

We study tunneling across a strain-induced superlattice in graphene. In studying the effect of applied strain on the low-lying Dirac-like spectrum, both a shift of the Dirac points in reciprocal space, and a deformation of the Dirac cones is explicitly considered. The latter corresponds to an anisotropic, possibly nonuniform, Fermi velocity. Along with the modes with unit transmission usually found across a single barrier, we analytically find additional resonant modes when considering a periodic structure of several strain-induced barriers. We also study the bandlike spectrum of bound states, as a function of conserved energy and transverse momentum. Such a strain-induced superlattice may thus effectively work as a mode filter for transport in graphene.

ArXiv: 1203.1094

Energy spectrum and Landau levels in bilayer graphene with spin-orbit interaction

Francisco Mireles,[1,2] and John Schliemann[1]

(1) U. Regensburg; (2) Universidad Nacional Autnoma de Mxico

We present a theoretical study of the bandstructure and Landau levels in bilayer graphene at low energies in the presence of a tranverse magnetic field and Rashba spin-orbit interaction. Within an effective low energy approach (L wdin o partitioning theory) we derive an effective Hamiltonian for bilayer graphene that incorporates the influence of the Zeeman effect, the Rashba spin-orbit interaction, and inclusively, the role of the intrinsic spin-orbit interaction at the same footing. Particular attention is spent to the energy spectrum and Landau levels. Our modeling unveils the strong influence of the Rashba coupling R in the spin-splitting of the electron and hole bands. We found that graphene bilayer with weak Rashba spin-orbit interaction shows a spin-splitting linear in momentum and proportional to R , but scales inversely proportional to the interlayer hopping energy 1 . However at robust spin-orbit coupling R the energy spectrum shows a strong warping behavior near the Dirac points. We find the bias-induced gap in bilayer graphene to be decreasing with increasing Rashba coupling, a behavior resembling a topological insulator transition. We further predicted an unexpected assymetric spin-splitting and crossings of the Landau levels due to the interplay between the Rashba interaction and the external bias voltage. Our results are of relevance for interpreting magnetotransport and infrared cyclotron resonance measurements, including also situations of comparatively weak spin-orbit coupling.

ArXiv: 1205.1441

Thermal metal-insulator transition in a helical topological superconductor

I. C. Fulga,[1] A. R. Akhmerov,[1] J. Tworzydlo,[2] B. Bri,[3] and C. W. J. Beenakker[1]

(1) Leiden, The Netherlands; (2) Warsaw, Poland; (3) Cavendish, UK

Two-dimensional superconductors with time-reversal symmetry have a Z2 topological invariant, that distinguishes phases with and without helical Majorana edge states. We study the topological phase transition in a class-DIII network model, and show that it is associated with a metal-insulator transition for the thermal conductance of the helical superconductor. The localization length diverges at the transition with critical exponent $\nu \approx 2.0$, about twice the known value in a chiral superconductor.

ArXiv: 1205.1910

Multi-qubit parity measurement in circuit quantum electrodynamics

David P. DiVincenzo and Firat Solgun

RWTH Aachen and Forschungszentrum Juelich, Germany

We present a scheme for performing three-qubit parity measurements in a microwave circuit with superconducting resonators coupled to Josephson-junction qubits. The magnitude of the coupling is the same as achieved in current experiments, but each qubit should be coupled equally to two different microwave cavities. We write the quantum-eraser conditions that must be fulfilled for the parity measurements as requirements for the scatttering phase shift of our microwave structure. We show that these conditions are fulfilled for realistic values of device elements. A quantum calculation indicates that the measurement is optimal if the scattering signal can be measured with near single photon sensitivity. A comparison with an extension of a related proposal from cavity optics is presented. Extension of our scheme to four or more qubits, and to 3D cavity structures, is discussed.

Nature **485**, 82 (2012)

Spinorbital separation in the quasi-one-dimensional Mott insulator Sr2CuO3

J. Schlappa,[1,2] K. Wohlfeld,[3] K. J. Zhou,[1] M. Mourigal,[4] M. W. Haverkort,[5] V. N. Strocov,[1] L. Hozoi,[3] C. Monney,[1] S. Nishimoto,[3] S. Singh[6], A. Revcolevschi,[6] J.-S. Caux,[7] L. Patthey,[1,8] H. M. Ronnow,[4] J. van den

Brink,[3] and T. Schmitt[1]

(1) Paul Scherrer Institut, Villigen, Switzerland; (2) Institut Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung G-I2, Berlin, Germany; (3) Institute for Theoretical Solid State Physics, Dresden, Germany; (4) Ecole Polytechnique Fdrale de Lausanne; (5) Max Planck Institute for Solid State Research, Stuttgart, Germany; (6) Universite Paris-Sud 11, Orsay; (7) Institute for Theoretical Physics, Amsterdam; (8) SwissFEL, Villigen, Switzerland

When viewed as an elementary particle, the electron has spin and charge. When binding to the atomic nucleus, it also acquires an angular momentum quantum number corresponding to the quantized atomic orbital it occupies. Even if electrons in solids form bands and delocalize from the nuclei, in Mott insulators they retain their three fundamental quantum numbers: spin, charge and orbital1. The hallmark of one-dimensional physics is a break- ing up of the elementary electron into its separate degrees of freedom2. The separation of the electron into independent quasi- particles that carry either spin (spinons) or charge (holons) was first observed fifteen years ago3. Here we report observation of the separation of the orbital degree of freedom (orbiton) using resonant inelastic X-ray scattering on the one-dimensional Mott insulator Sr2CuO3. We resolve an orbiton separating itself from spinons and propagating through the lattice as a distinct quasi- particle with a substantial dispersion in energy over momentum, of about 0.2 electronvolts, over nearly one Brillouin zone.

Physical Review B **85**, 205107 (2012)

Composite spin liquid in a correlated topological insulator: Spin liquid without spin-charge separation

Jing He, Ying Liang, and Su-Peng Kou

Beijing Normal University, China

In this paper, we present an alternative type of insulator, namely composite spin liquid, which can be regarded as a short-range B-type topological spin-density wave as proposed by J. He et al. [Phys. Rev. B 84, 035127 (2011)]. Composite spin liquid is a topological ordered state beyond the classification of traditional spin liquid states. The elementary excitations are the composite electrons with both spin and charge degrees of freedom, together with topological spin texture. This topological state supports the chiral edge mode but no topological degeneracy.

Physical Review Letters **108**, 181807 (2012)

Spacetime as a Topological Insulator: Mechanism for the Origin of the Fermion Generations

David B. Kaplan, and Sichun Sun

Institute for Nuclear Theory, University of Washington, USA

We suggest a mechanism whereby the three generations of quarks and leptons correspond to surface modes in a five-dimensional theory. These modes arise from a nonlinear fermion dispersion relation in the extra dimension, much in the same manner as fermion surface modes in a topological insulator or lattice implementation of domain wall fermions. We also show that the topological properties can persist in a deconstructed version of the model in four dimensions.

Physical Review Letters **108**, 196801 (2012)

Direct Observation of Interband Spin-Orbit Coupling in a Two-Dimensional Electron System

Hendrik Bentmann,[1,2] Samir Abdelouahed,[3] Mattia Mulazzi,[1,2] Jurgen Henk,[4] and Friedrich Reinert[1,2]

(1) Wurzburg, Germany; (2) Karlsruhe, Germany; (3) Texas A&M University at Qatar; (4) Halle (Saale), Germany

We report the direct observation of interband spin-orbit (SO) coupling in a two-dimensional (2D) surface electron system, in addition to the anticipated Rashba spin splitting. Using angle-resolved photoemission experiments and first-principles calculations on Bi-Ag-Au heterostructures, we show that the effect strongly modifies the dispersion as well as the orbital and spin character of the 2D electronic states, thus giving rise to considerable deviations from the Rashba model. The strength of the interband SO coupling is tuned by the thickness of the thin film structures.

Reviews of Modern Physics **84**, 621 (2012)

Gaussian quantum information

Christian Weedbrookm, Stefano Pirandola, Ral Garca-Patrn, Nicolas J. Cerf, Timothy C. Ralph, Jeffrey H. Shapiro, Seth Lloyd

(1) University of Toronto; (2) MIT; (3) University of York; (4) Max-Planck-Institut fr Quantenoptik; (5) Universit Libre de Bruxelles; (6) University of Queensland

---

Physical Review Letters **108**, 196804 (2012)

Electric-field-induced Majorana Fermions in Armchair Carbon Nanotubes

Jelena Klinovaja, Suhas Gangadharaiah, and Daniel Loss

University of Basel

Physical Review B **85**, 195412 (2012)

Bias-dependent Dyakonov-Perel spin relaxation in bilayer graphene

Mathias Diez and Guido Burkard

University of Konstanz, Germany