Universal decoherence due to gravitational time dilation

Igor Pikovski, Magdalena Zych, Fabio Costa and Caslav Brukner, Nature Physics (2015) doi:10.1038/nphys3366

The physics of low-energy quantum systems is usually studied without explicit consideration of the background spacetime. Phenomena inherent to quantum theory in curved spacetime, such as Hawking radiation, are typically assumed to be relevant only for extreme physical conditions: at high energies and in strong gravitational fields. Here we consider low-energy quantum mechanics in the presence of gravitational time dilation and show that the latter leads to the decoherence of quantum superpositions. Time dilation induces a universal coupling between the internal degrees of freedom and the centre of mass of a composite particle. The resulting correlations lead to decoherence in the particle position, even without any external environment. We also show that the weak time dilation on Earth is already sufficient to affect micrometre-scale objects. Gravity can therefore account for the emergence of classicality and this effect could in principle be tested in future matter-wave experiments.

Non-universal weak antilocalization effect in cubic topological Kondo insulators

Maxim Dzero, Maxim G. Vavilov, Kostyantyn Kechedzhi, Victor Galitski, arXiv:1507.01878

We study the quantum correction to conductivity on the surface of cubic topological Kondo insulators with multiple Dirac bands. We consider the model of time-reversal invariant disorder which induces the scattering of the electrons within the Dirac bands as well as between the bands. When only intraband scattering is present we find three long-range diffusion modes which lead to weak antilocalization correction to conductivity, which remains independent of the microscopic details such as Fermi velocities and relaxation times. Interband scattering gaps out two diffusion modes leaving only one long-range mode. We find that depending on the value of the phase coherence time, either three or only one long-range diffusion modes contribute to weak localization correction rendering the quantum correction to conductivity non-universal. We provide an interpretation for the results of the recent transport experiments on samarium hexaboride where weak antilocalization has been observed.

Bending Rules for Nano-Kirigami

Bastien F. Grosso, E. J. Mele arXiv:1507.01805

We combine large-scale atomistic modelling with continuum elastic theory to study the shapes of graphene sheets embedding nanoscale kirigami. Lattice segments are selectively removed from a flat graphene sheet and the structure is allowed to close and reconstruct by relaxing in the third dimension. The surface relaxation is limited by a nonzero bending modulus which produces a smoothly modulated landscape instead of the ridge-and-plateau motif found in macroscopic lattice kirigami. The resulting surface shapes and their interactions are well described by a new set of microscopic kirigami rules that resolve the competition between the bending and stretching energies.

Tunneling current noise in the fractional quantum Hall effect: when the effective charge is not what it appears to be

Kyrylo Snizhko, arXiv:1507.01961

Fractional quantum Hall quasiparticles are famous for having fractional electric charge. Recent experiments report that the quasiparticles' effective electric charge determined through tunneling current noise measurements can depend on the system parameters such as temperature or bias voltage. Several works proposed to understand this as a signature for edge theory properties changing with energy scale. I consider two of such experiments and show that in one of them the apparent dependence of the electric charge on a system parameter is likely to be an artefact of experimental data analysis. Conversely, in the second experiment the dependence cannot be explained in such a way.

Prethermal Floquet steady-states and instabilities in the periodically-driven, weakly-interacting Bose-Hubbard model

M. Bukov, S. Gopalakrishnan, M. Knap, E. Demler, arXiv:1404.0485

We explore the prethermal Floquet steady-states and instabilities of the weakly interacting two-dimensional Bose Hubbard model subject to periodic driving. We develop a description of the nonequilibrium dynamics using a weak-coupling conserving approximation. This approach allows us to explore dynamics at arbitrary drive strength and frequency. We establish the regimes in which conventional (zero-momentum) and unconventional ((π,π)-momentum) condensates are stable on intermediate time scales. We find that the condensate stability is *enhanced* by increasing the drive strength, because this decreases the bandwidth of quasiparticle excitations and thus impedes resonant absorption and heating. Our results are directly relevant to a number of current experiments with ultracold lattice bosons.

Berry phase and anomalous velocity of Weyl fermions and Maxwell photons

Michael Stone, arXiv:1507.01807

We consider two systems of wave equations whose wavepacket solutions have trajectories that are altered by the "anomalous velocity" effect of a Berry curvature. The first is the matrix Weyl equation describing cyclotron motion of a charged massless fermion. The second is Maxwell equations for the whispering-gallery modes of light in a cylindrical waveguide. In the case of the massless fermion, the anomalous velocity is obscured by the contribution from the magnetic moment. In the whispering gallery modes the anomalous velocity causes the circumferential light ray to creep up the cylinder at the rate of one wavelength per orbit, and can be identified as a continuous version of the Imbert-Federov effect.

Effect of disorder in three dimensional layered Chern insulator

Shang Liu, Tomi Ohtsuki, Ryuichi Shindou,

arXiv:1507.02381

We studied the effects of disorder in a three dimensional layered Chern insulator, which, in the clean limit, is either Chern insulator (CI) or Weyl semimetal (WSM) depending on an interlayer coupling strength. By calculating the localization length by the transfer matrix method, we found two distict types of metallic phases between Anderson insulator and Chern insulator; one is diffusive metallic phase and the other is renormalized Weyl semimetal phase. By calculating the conductance and density of states, we characterize these two metallic phases and reveal a critical nature of a quantum critical line between these two metallic phases.

Spontaneous formation of bright solitons in self-localized impurities in Bose-Einstein condensate

Abdelaali Boudjemaa, arXiv:1507.02552

We study the formation of bright solitons in the impurity component of Bose-Einstein condensate (BEC)-impurity mixture by using the time-dependent Hartree-Fock-Bogoliubov theory. While we assume the boson-boson and impurity-boson interactions to be effectively repulsive, their character can be changed spontaneously from repulsive to attractive in the presence of strong anomalous correlations. In such a regime the impurity component becomes a system of effectively attractive atoms leading automatically to the generation of bright solitons. We find that this soliton decays at higher temperatures due to the dissipation induced by the impurity-host and host-host interactions. We show that after a sudden increase of the impurity-boson strength a train of bright solitons is produced and this can be interpreted in terms of the modulational instability (MI) of the time-dependent impurity wave function.

Triplet proximity effect in superconducting heterostructures with a half-metallic layer

S. Mironov, A. Buzdin, arXiv:1507.02429

We present the Usadel theory describing the superconducting proximity effect in heterostructures with a half-metallic layer. It is shown that the full spin polarization inside the half-metals gives rise to the giant triplet spin-valve effect in superconductor (S) - ferromagnet (F) - half-metal (HM) trilayers as well as to the 0-junction formation in the S/F/HM/F/S systems. In addition, we consider the exactly solvable model of the S/F/HM trilayers of atomic thickness and demonstrate that it reproduces the main features of the spin-valve effect found within the Usadel approach. Our results are shown to be in a qualitative agreement with the recent experimental data on the spin-valve effect in MoGe/Cu/Ni/CrO2 hybrids [A. Singh et al., Phys. Rev. X 5, 021019 (2015)].

Dynamics of Fractionalization in Quantum Spin Liquids

J. Knolle, D.L. Kovrizhin, J.T. Chalker, R. Moessner, arXiv:1507.02865

We present the theory of dynamical spin-response for the Kitaev honeycomb model, obtaining exact results for the structure factor (SF) in gapped and gapless, Abelian and non-Abelian quantum spin-liquid (QSL) phases. We also describe the advances in methodology necessary to compute these results. The structure factor shows signatures of spin-fractionalization into emergent quasiparticles – Majorana fermions and fluxes of Z2 gauge field. In addition to a broad continuum from spin-fractionalization, we find sharp (-function) features in the response. These arise in two distinct ways: from excited states containing only (static) fluxes and no (mobile) fermions; and from excited states in which fermions are bound to fluxes. The SF is markedly different in Abelian and non-Abelian QSLs, and bound fermion-flux composites appear only in the non-Abelian phase.

Nambu-Goldstone Effective Theory of Information at Quantum Criticality

Gia Dvali, Andre Franca, Cesar Gomez, Nico Wintergerst, arXiv:1507.02948

We establish a fundamental connection between quantum criticality of a many-body system, such as Bose-Einstein condensates, and its capacity of information-storage and processing. For deriving the effective theory of modes in the vicinity of the quantum critical point we develop a new method by mapping a Bose-Einstein condensate of N-particles onto a sigma model with a continuous global (pseudo)symmetry that mixes bosons of different momenta. The Bogolyubov modes of the condensate are mapped onto the Goldstone modes of the sigma model, which become gapless at the critical point. These gapless Goldstone modes are the quantum carriers of information and entropy. Analyzing their effective theory, we observe the information-processing properties strikingly similar to the ones predicted by the black hole portrait. The energy cost per qubit of information-storage vanishes in the large-N limit and the total information-storage capacity increases with N either exponentially or as a power law. The longevity of information-storage also increases with N, whereas the scrambling time in the over-critical regime is controlled by the Lyapunov exponent and scales logarithmically with N. This connection reveals that the origin of black hole information storage lies in the quantum criticality of the graviton Bose-gas, and that much simpler systems that can be manufactured in table-top experiments can exhibit very similar information-processing dynamics.