

Chirality density wave of the ‘hidden order’ phase in URu₂Si₂

H.-H. Kung et al., Scienceexpress DOI: 10.1126/science.1259729

A second-order phase transition is associated with emergence of an “order parameter” and a spontaneous symmetry breaking. For the heavy fermion superconductor URu₂Si₂, the symmetry of the order parameter associated with its ordered phase below 17.5 K has remained ambiguous despite 30 years of research, and hence is called “hidden order” (HO). Here we use polarization resolved Raman spectroscopy to specify the symmetry of the low energy excitations above and below the HO transition. These excitations involve transitions between interacting heavy uranium *5f* orbitals, responsible for the broken symmetry in the HO phase. From the symmetry analysis of the collective mode, we determine that the HO parameter breaks local vertical and diagonal reflection symmetries at the uranium sites, resulting in crystal field states with distinct chiral properties, which order to a commensurate chirality density wave ground state.

Spatially structured photons that travel in free space slower than the speed of light

Daniel Giovannini et al., Science **347**, 857 (2015).

That the speed of light in free space is constant is a cornerstone of modern physics. However, light beams have finite transverse size, which leads to a modification of their wave vectors resulting in a change to their phase and group velocities. We study the group velocity of single photons by measuring a change in their arrival time that results from changing the beams transverse spatial structure. Using time-correlated photon pairs, we show a reduction in the group velocity of photons in both a Bessel beam and photons in a focused Gaussian beam. In both cases, the delay is several micrometers over a propagation distance of 1 meter. Our work highlights that, even in free space, the invariance of the speed of light only applies to plane waves.

Microwave Quantum Illumination

Shabir Barzanjeh et al., Phys. Rev. Lett. **114**, 080503 (2015)

Quantum illumination is a quantum-optical sensing technique in which an entangled source is exploited to improve the detection of a low-reflectivity object that is immersed in a bright thermal background. Here, we describe and analyze a system for applying this technique at microwave frequencies, a more appropriate spectral region for target detection than the optical, due to the naturally occurring bright thermal background in the microwave regime. We use an electro-optomechanical converter to entangle microwave signal and optical idler fields, with the former being sent to probe the target region and the latter being retained at the source. The microwave radiation collected from the target region is then phase conjugated and upconverted into an optical field that is combined with the retained idler in a joint-detection quantum measurement. The error probability of this microwave quantum-illumination system, or quantum radar, is shown to be superior to that of any classical microwave radar of equal

transmitted energy.

Gravitational Casimir Effect

James Q. Quach, Phys. Rev. Lett. **114**, 081104 (2015)

We derive the gravitonic Casimir effect with nonidealized boundary conditions. This allows the quantification of the gravitonic contribution to the Casimir effect from real bodies. We quantify the meagerness of the gravitonic Casimir effect in ordinary matter. We also quantify the enhanced effect produced by the speculated Heisenberg-Coulomb (HC) effect in superconductors, thereby providing a test for the validity of the HC theory, and, consequently, the existence of gravitons.

Topology versus Anderson localization: Nonperturbative solutions in one dimension

Alexander Altland, Dmitry Bagrets, and Alex Kamenev, Phys. Rev. B **91**, 085429 (2015)

We present an analytic theory of quantum criticality in quasi-one-dimensional topological Anderson insulators. We describe these systems in terms of two parameters (g, χ) representing localization and topological properties, respectively. Certain critical values of χ (half-integer for Z classes, or zero for Z_2 classes) define phase boundaries between distinct topological sectors. Upon increasing system size, the two parameters exhibit flow similar to the celebrated two-parameter flow of the integer quantum Hall insulator. However, unlike the quantum Hall system, an exact analytical description of the entire phase diagram can be given in terms of the transfer-matrix solution of corresponding supersymmetric nonlinear sigma models. In Z_2 classes we uncover a hidden supersymmetry, present at the quantum critical point.

Anomalous conductivity tensor in the Dirac semimetal Na₃Bi

Jun Xiong, Satya Kushwaha, Jason Krizan, Tian Liang, R. J. Cava, and N. P. Ong, arXiv:1502.06266

Na₃Bi is a Dirac semimetal with protected nodes that may be sensitive to the breaking of time-reversal invariance in a magnetic field B . We report experiments which reveal that both the conductivity and resistivity tensors exhibit robust anomalies in B . The resistivity ρ_{xx} is B -linear up to 35 T, while the Hall angle exhibits an unusual profile approaching a step-function. The conductivities σ_{xx} and σ_{xy} share identical power-law dependences at large B . We propose that these significant deviations from conventional transport result from an unusual sensitivity of the transport lifetime to B . Comparison with Cd₃As₂ is made.

Absence of Josephson coupling between certain superconductors

J. E. Hirsch, arXiv:1502.07059

It is generally believed that superconductivity can occur in materials irrespective of whether the charge carriers in the material are electrons or holes. Here we point out that Josephson tunneling would not occur between superconductors with charge carriers of opposite sign. Consequently, observation of Josephson tunneling between two superconductors implies

that their charge carriers have the same sign. We propose that this has profound implications for the understanding of superconductivity and in particular is consistent with the theory of hole superconductivity.

Quasi One Dimensional Pair Density Wave Superconducting State

Rodrigo Soto-Garrido, Gil Young Cho, Eduardo Fradkin, arXiv:1502.07349

We provide a quasi-one-dimensional model which can support a pair-density-wave (PDW) state, in which the superconducting (SC) order parameter modulates periodically in space, with gapless Bogoliubov quasiparticle excitations. The model consists of an array of strongly-interacting one-dimensional systems, where the one-dimensional systems are coupled to each other by local interactions and tunneling of the electrons and Cooper pairs between them. Within the interchain mean-field theory, we find several SC states from the model, including a conventional uniform SC state, PDW SC state, and a coexisting phase of the uniform SC and PDW states. In this quasi-1D regime we can treat the strong correlation physics essentially exactly using bosonization methods and the crossover to the 2D system by means of interchain mean field theory. The resulting critical temperatures of the SC phases generically exhibit a power-law scaling with the coupling constants of the array, instead of the essential singularity found in weak-coupling BCS-type theories. Electronic excitations with an open Fermi surface, which emerge from the electronic Luttinger liquid systems below their crossover temperature to the Fermi liquid, are then coupled to the SC order parameters via the proximity effect. From the Fermi surface thus coupled to the SC order parameters, we calculate the quasiparticle spectrum in detail. We show that the quasiparticle spectrum can be fully gapped or nodal in the uniform SC phase and also in the coexisting phase of the uniform SC and PDW parameters. In the pure PDW state, the excitation spectrum has a reconstructed Fermi surface in the form of Fermi pockets of Bogoliubov quasiparticles.

Exact correspondence between Renyi entropy flows and physical flows

Mohammad H. Ansari, Yuli V. Nazarov, arXiv:1502.08020

We present a universal relation between the flow of a Renyi entropy and the full counting statistics of energy transfers. We prove the exact relation for a flow to a system in thermal equilibrium that is weakly coupled to an arbitrary time-dependent and non-equilibrium system. The exact correspondence, given by this relation, provides a simple protocol to quantify the flows of Shannon and Renyi entropies from the measurements of energy transfer statistics.

Incompressible polaritons in a flat bands

Matteo Biondi, Evert P. L. van Nieuwenburg, Gianni Blatter, Sebastian D. Huber, Sebastian Schmidt, arXiv:1502.07854

We study the interplay of geometric frustration and interac-

tions in a non-equilibrium photonic lattice system exhibiting a polariton flat band as described by a variant of the Jaynes-Cummings-Hubbard model. We develop a semi-analytic projective method and employ an open system version of the time-evolving block decimation algorithm (TEBD) in order to calculate the non-equilibrium steady state of the array subject to drive and dissipation. We find that frustration strongly enhances photon repulsion in a flat band leading to an incompressible state of light. The latter manifests itself in strong spatial correlations, i.e., on-site and nearest-neighbor antibunching combined with extended density-wave oscillations at larger distances. We propose a state-of-the-art circuit QED realization of our system, which is tunable in-situ.

Low-frequency conductivity in many-body localized systems

Sarang Gopalakrishnan, Markus Mueller, Vedika Khemani, Michael Knap, Eugene Demler, David A. Huse, arXiv:1404.1707

We argue that the a.c. conductivity $\sigma(\omega)$ in the many-body localized phase is a power law of frequency ω at low frequency: specifically, $\sigma(\omega) \sim \omega^\alpha$ with the exponent α approaching 1 at the phase transition to the thermal phase, and asymptoting to 2 deep in the localized phase. We identify two separate mechanisms giving rise to this power law: deep in the localized phase, the conductivity is dominated by rare resonant pairs of configurations; close to the transition, the dominant contributions are rare regions that are locally critical or in the thermal phase. We present numerical evidence supporting these claims, and discuss how these power laws can also be seen through polarization-decay measurements in ultracold atomic systems.

Spin-lattice order in one-dimensional conductors: beyond the RKKY effect

Michael Schechter, Mark S. Rudner, Karsten Flensberg, arXiv:1502.07362

We investigate magnetic order in a lattice of classical spins coupled to an isotropic gas of one-dimensional (1d) conduction electrons via local exchange interactions. The frequently discussed Ruderman-Kittel-Kasuya-Yosida (RKKY) effective exchange model for this system predicts that spiral order is always preferred. Here we consider the problem nonperturbatively, and find that such order vanishes above a critical value of the exchange coupling that depends strongly on the lattice spacing. The critical coupling tends to zero as the lattice spacing becomes commensurate with the Fermi wave vector, signalling the breakdown of the perturbative RKKY picture, and spiral order, even at weak coupling. We provide the exact phase diagram for arbitrary exchange coupling and lattice spacing, and discuss its stability. Our results shed new light on the problem of utilizing a spiral spin-lattice state to drive a one-dimensional superconductor into a topological phase.