Reversible and efficient conversion between microwave and optical light
R. W. Andrews, R. W. Peterson, T. P. Purdy, K. Cicak, R. W. Simmonds, C. A. Regal, K. W. Lehnert, arXiv:1310.5276 [physics.optics]
Converting low-frequency electrical signals into much higher frequency optical signals has enabled modern communications networks to leverage both the strengths of microfabricated electrical circuits and optical fiber transmission, allowing information networks to grow in size and complexity. A microwave-to-optical converter in a quantum information network could provide similar gains by linking quantum processors via low-loss optical fibers and enabling a large-scale quantum network. However, no current technology can convert low-frequency microwave signals into high-frequency optical signals while preserving their fragile quantum state. For this demanding application, a converter must provide a near-unitary transformation between different frequencies; that is, the ideal transformation is reversible, coherent, and lossless. Here we demonstrate a converter that reversibly, coherently, and efficiently links the microwave and optical portions of the electromagnetic spectrum. We use our converter to transfer classical signals between microwave and optical light with conversion efficiencies of 10%, and achieve performance sufficient to transfer quantum states if the device were further precooled from its current 4 kelvin operating temperature to below 40 millikelvin. The converter uses a mechanically compliant membrane to interface optical light with superconducting microwave circuitry, and this unique combination of technologies may provide a way to link distant nodes of a quantum information network.

Photonic Cavity Synchronization of Nanomechanical Oscillators
M. Bagheri, M. Poot, L. Fan, F. Marquardt, H. X. Tang, arXiv:1310.4750 [physics.optics]
Synchronization in oscillatory systems is a frequent natural phenomenon and is becoming an important concept in modern physics. Nanomechanical resonators are ideal systems for studying synchronization due to their controllable oscillation properties and engineerable nonlinearities. Here we demonstrate synchronization of two nanomechanical oscillators via a photonic resonator, enabling optomechanical synchronization between mechanically isolated nanomechanical resonators. Optical backaction gives rise to both reactive and dissipative coupling of the mechanical resonators, leading to coherent oscillation and mutual locking of resonators with dynamics beyond the widely accepted phase oscillator (Kuramoto) model. Besides the phase difference between the oscillators, also their amplitudes are coupled, resulting in the emergence of sidebands around the synchronized carrier signal.

The Fisher information for measurements on open quantum systems
Søren Gammelmark, Klaus Mølmer, arXiv:1310.5802 [quant-ph]
The quantum Cramer-Rao bound relates estimation sensitivity in quantum precision measurements to the distinguishability of different quantum states. We show that the theoretical sensitivity limit to parameters that govern the dynamics of an open quantum system coupled to a fully quantized environment can be evaluated from the reduced system master equation. We provide the bound for a laser driven two-state atom, where photon counting and homodyne detection of the fluorescence signal yield different sensitivity to the atomic and field parameters, while none of them exceed our general sensitivity limit.

A single photon transistor based on superconducting systems
Marco T. Manzoni, Florentin Reiter, Jacob Taylor, Anders S. Sørensen, arXiv:1310.6553 [quant-ph]
In analogy with electronic transistors, a single photon transistor is a device where the presence or absence of a single gate photon controls the propagation of a large number of signal photons. Such devices would represent a milestone enabling a plethora of new approaches for processing light, but their realization is hampered by the absence of interactions between photons. A promising route towards strong interactions at the single photon level consists of coupling propagating photons to individual atom-like systems. The best realization of such a coupling is achieved in the microwave regime where experiments have demonstrated an unprecedented control of the coupling between superconducting artificial atoms and microwave photons. In this letter we describe how to realize a single photon transistor based on existing superconducting technology. The resulting devices can be directly employed to detect individual itinerant microwave photons, and may find a range of applications within quantum information processing.

Control of Majorana Edge Modes by a g-factor Engineered Nanowire Spin Transistor
Amrit De, Alexey A. Kovalev, arXiv:1310.5847 [cond-mat.mes-hall]
We propose the manipulation of Majorana edge states via hybridization and spin currents in a nanowire spin transistor. The spin transistor is based on a heterostructure nanowire comprising of semiconductors with large and small g-factors that form the topological and non-topological regions respectively. The hybridization of bound edge states results in spin currents and 4π-periodic torques, as a function of the relative magnetic field angle – an effect

which is dual to the fractional Josephson effect. We establish relation between torques and spin-currents in the non-topological region where the magnetic field is almost zero and spin is conserved along the spin-orbit field direction. The angular momentum transfer could be detected by sensitive magnetic resonance force microscopy techniques.

Radiative topological states in resonant photonic crystals

A. V. Poshakinskiy, A. N. Poddubny, L. Pilozzi, E. L. Ivchenko, arXiv:1310.7432 [cond-mat.mes-hall]

We present a theory of topological edge states in one-dimensional resonant photonic crystals with a compound unit cell. Contrary to the traditional electronic topological states the states under consideration are radiative, i.e., they decay in time due to the light escape through the structure boundaries. We demonstrate that the states survive despite their radiative decay and can be detected both in time- and frequency-dependent light reflection.

Measuring the Kondo Cloud by Current Cross Correlations in Helical Liquids

Thore Posske, Björn Trauzettel, The Kondo cloud, represented by the correlations between the magnetic moment and the spin density in the leads of a Kondo setup, is until now eluding its observation. We exploit the unique coupling of spin and direction of motion of the recently discovered helical liquids in a setup with two leads to establish a proportionality between the Kondo cloud and the time resolved current cross correlations. This relation holds around a specific choice of model parameters. Thereby, we provide a new and direct way to detect the Kondo cloud.

arXiv:1310.6750 [cond-mat.mes-hall]

Single-photon router: Coherent Control of multi-channel scattering for single-photons with quantum interferences

Jing Lu, Lan Zhou, Le-man Kuang, Franco Nori, arXiv:1310.7286 [quant-ph]

We propose a single-photon router using a single atom of an inversion center coupled to quantum multichannels made of coupled-resonator waveguides (CRWs). It is found that the spontaneous emission of the atom is used to redirect single photons from one quantum channel into another. The on-demand classical field perfectly switches-off the single-photon routing due to the quantum interference in the atomic amplitudes of optical transitions. Total reflections in the incident channel are due to the photonic bound state in the continuum. The virtual channels, named as scatter-free and controllable channels, are found, which are coherent superposition of quantum channels. Any incident photon in the scatter-free channel is totally transmitted. The propagating states of the controllable channel (CC) are orthogonal to those of the scatter-free channel. Single photons in the CC can be perfectly reflected or transmitted by the atom.

Tunable polarization in beam-splitter based on 2D topological insulators

Dietrich G. Rothe, Ewelina M. Hankiewicz, arXiv:1310.7213 [cond-mat.mes-hall]

The typical bulk model describing 2D topological insulators (TI) consists of two types of spin-orbit terms, the so-called Dirac term which induces out-of plane spin polarization and the Rashba term which induces in-plane spin polarization. We show that for some parameters of the Fermi energy, the beam splitter device built on 2D TIs can achieve higher in-plane spin polarization than one built on materials described by the Rashba model itself. Further, due to high tunability of the electron density and the asymmetry of the quantum well, spin polarization in different directions can be obtained. While in the normal (topologically trivial) regime the in-plane spin polarization would dominate, in the inverted regime the out-of-plane polarization is more significant not only in the band gap but also for small Fermi energies above the gap. Further, we suggest a double beam splitter scheme, to measure in-plane spin current all electrically. Although we consider here as an example HgTe/CdTe quantum wells, this scheme could be also promising for InAs/GaSb QWs where the in- and out-of-plane polarization could be achieved in a single device.

Weak measurements of imaginary weak values in the time and frequency domains

Yaron Kedem, arXiv:1310.6834 [quant-ph]

Weak measurements with imaginary weak values are reexamined in light of recent experimental results. The shift of the meter, due to the imaginary part of the weak value, is derived via the probability of postselection, which allows considering the meter as a distribution of a classical variable. The derivation results in a simple relation between the change in the distribution and its variance. By applying this relation to several experimental results, in which the meter involved the time and frequency domains, it is shown to be especially suitable for scenarios of that kind. The practical and conceptual implications of a measurement method, which is based on this relation, are discussed.