Measurement-Induced Macroscopic Superposition States in Cavity Optomechanics

A novel protocol for generating quantum superpositions of macroscopically distinct states of a bulk mechanical oscillator is proposed, compatible with existing optomechanical devices operating in the bad-cavity limit. By combining a pulsed optomechanical quantum nondemolition (QND) interaction with nonclassical optical resources and measurement-induced feedback, the need for strong single-photon coupling is avoided. We outline a three-pulse sequence of QND interactions encompassing squeezing-enhanced cooling by measurement, state preparation, and tomography.
Assessments of macroscopicity for quantum optical states

With the slow but constant progress in the coherent control of quantum systems, it is now possible to create large quantum superpositions. There has therefore been an increased interest in quantifying any claims of macroscopicity. We attempt here to motivate three criteria which we believe should enter in the assessment of macroscopic quantunness: The number of quantum fluctuation photons, the purity of the states, and the ease with which the branches making up the state can be distinguished. © 2014.
Hybrid discrete- and continuous-variable quantum information

Research in quantum information processing has followed two different directions: the use of discrete variables (qubits) and that of high-dimensional, continuous-variable Gaussian states (coherent and squeezed states). Recently, these two approaches have been converging in potentially more powerful hybrid protocols.

General information
State: Published
Organisations: Department of Physics, Quantum Physics and Information Technology, Johannes Gutenberg-Universität, University of Tokyo
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Scopus rating (2008): SJR 10.014 SNIP 4.58
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Increasing the photon collection rate from a single NV center with a silver mirror

In the pursuit of realizing quantum optical networks, a large variety of different approaches have been studied to achieve a single photon source on-demand. The common goal for these approaches is to harvest all the emission from a quantum emitter into a single spatial optical mode while maintaining a high signal-to-noise ratio. In this work, we use a single nitrogen vacancy center in diamond as a quantum emitter operating at ambient conditions and we demonstrate an increased photon count rate up to a factor of 1.76 by placing a silver mirror fabricated on the end facet of an optical fiber near the emitter.
Amplification of realistic Schrödinger-cat-state-like states by homodyne heralding

We present a scheme for the amplification of Schrödinger cat states that collapses two smaller states onto their constructive interference via a homodyne projection. We analyze the performance of the amplification in terms of fidelity and success rate when the input consists of either exact coherent state superpositions or of photon-subtracted squeezed vacua. The impact of imprecise homodyne detection and of impure squeezing is quantified. We also assess the scalability of iterated amplifications.

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A Variable Single Photon Plasmonic Beamsplitter
Plasmonic structures can both be exploited for scaling down optical components beyond the diffraction limit and enhancing and collecting the emission from a single dipole emitter. Here, we experimentally demonstrate adiabatic coupling between two silver nanowires using a nitrogen vacancy center as a probe source.

General information
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Organisations: Department of Photonics Engineering, Fiber Sensors and Supercontinuum Generation, Quantum Physics and Information Technology, Department of Physics
Authors: Israelsen, N. M. (Intern), Kumar, S. (Intern), Huck, A. (Intern), Neergaard-Nielsen, J. S. (Intern), Andersen, U. L. (Intern)
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Displacement-enhanced entanglement distillation of single-mode-squeezed entangled states
It has been shown that entanglement distillation of Gaussian entangled states by means of local photon subtraction can be improved by local Gaussian transformations. Here we show that a similar effect can be expected for the distillation of an asymmetric Gaussian entangled state that is produced by a single squeezed beam. We show that for low initial entanglement, our largely simplified protocol generates more entanglement than previous proposed protocols. Furthermore, we show that the distillation scheme also works efficiently on decohered entangled states as well as with a practical photon subtraction setup.

General information
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Organisations: Department of Physics, Quantum Physics and Information Technology
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Heralded generation of a micro-macro entangled state

Using different optical setups based on squeezed state and photon subtraction we show how optical entanglement between a macroscopic and a microscopic state—the so-called Schrödinger cat state or micro-macro state—can be generated. The entangled state is heralded and is thus produced a priori in contrast to previous proposals. We define the macroscopicity of the macroscopic part of the state as their mean distance in phase space and the success rate in discriminating them with homodyne detection, and subsequently, based on these measures we investigate the macroscopicity of different states. Furthermore, we show that the state can be used to map a microscopic qubit onto a macroscopic one thereby linking a qubit processor with a qumode processor.
Measurement-induced amplification of optical cat-like states

Coherent state superpositions, also known as Schrödinger cat states, are widely recognized as promising resources in quantum information, quantum metrology, as well as fundamental tests. These states are hard to produce deterministically and most schemes for their probabilistic generation can only attain amplitudes too small for practical use. This is for example the case for photon-subtracted squeezed vacuum (PSSV), which can be used to approximate cat states of amplitude no larger than $y = 1.5$ if the fidelity is to be maintained above 95%. One way to reach larger amplitudes is to start with pairs of small cats and then to interfere them on a balanced beam splitter. The projective measurement of one of the outputs is used to herald a larger cat resulting from the constructive interference of the initial states. The scheme proposed here uses the projection $|x = 0\rangle\langle x = 0|$ as the heralding condition. Homodyning is proposed, as opposed to photon counting, because homodyne detection has high a quantum efficiency, and - as demonstrated in the paper - can be tuned to increase the success probability of the amplification without heavily compromising the output's fidelity.

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Quantum tele-amplification with a continuous-variable superposition state

Optical coherent states are classical light fields with high purity, and are essential carriers of information in optical networks. If these states could be controlled in the quantum regime, allowing for their quantum superposition (referred to as a Schrödinger-cat state), then novel quantum-enhanced functions such as coherent-state quantum computing (CSQC), quantum metrology and a quantum repeater could be realized in the networks. Optical cat states are now routinely generated in laboratories. An important next challenge is to use them for implementing the aforementioned functions. Here, we demonstrate a basic CSQC protocol, where a cat state is used as an entanglement resource for teleporting a coherent state with an amplitude gain. We also show how this can be extended to a loss-tolerant quantum relay of multiary phase-shift keyed coherent states. These protocols could be useful in both optical and quantum communications.

General information
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Scopus rating (2010): SJR 10.754 SNIP 8.328
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Projects:

**Non-Gaussian Cluster States**
Department of Physics
Period: 01/10/2017 → 30/09/2020
Number of participants: 3
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Supervisor:
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Main Supervisor:
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**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

**Quantum Communication with non-Gaussian states**
Department of Physics
Period: 01/04/2017 → 31/03/2020
Number of participants: 3
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