Quantum information

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PROGRAM DESCRIPTION

The research program in quantum information theory is directed towards general aspects of quantum information, such as entanglement, decoherence and error correction, with a particular emphasis on condensed matter systems and quantum optics.

Quantum Information

We completed the study of intracavity weak nonlinear phase shifts with single photon driving, in collaboration with W. J. Munro at HP Labs, Bristol and K. Nemoto, at the National Institute for Informatics in Tokyo. We investigated a doubly resonant optical cavity containing a Kerr nonlinear medium that couples two modes by a cross phase modulation. One of these modes is driven by a single photon pulsed field, and the other mode is driven by a coherent state. We showed that there is an intrinsic phase noise mechanism for the cross phase shift on the coherent beam that can be attributed to the random emission times of single photons from the cavity. An application to the weak nonlinearity phase gate was investigated. The device functions as a reliable conditional phase shift gate provided the lifetime of the single photon is much shorter than the lifetime of the coherent field. This work is published in Optics Communications, and was available online on November 5, 2009. A new approach to linear optical quantum computing was commenced which enables one to consider simulating a variety of nonlinear quantum field theories.

A preliminary study of coherent state quantum gates was undertaken in the context of superconducting circuits and the first results were published in "Photons as qubits", G. J. Milburn, Phys. Scr. T **137**, 014003 (2009). In collaboration with M. Stobinska, we undertook a preliminary investigation of single-electron carbon nanotube quantum dots with significant spin-orbit interaction as a scalable quantum computer candidate. Both electron spin and orbital angular momentum can serve as a logical qubit for quantum processing. The preliminary report can be found at http://arxiv.org/abs/0912.3547. In an ongoing study of quantum information in a general relativistic setting we have derived various quantum limits to estimating the single parameter Schwarzschild metric for arbitrary quantum fields generalising an earlier result of Unruh.

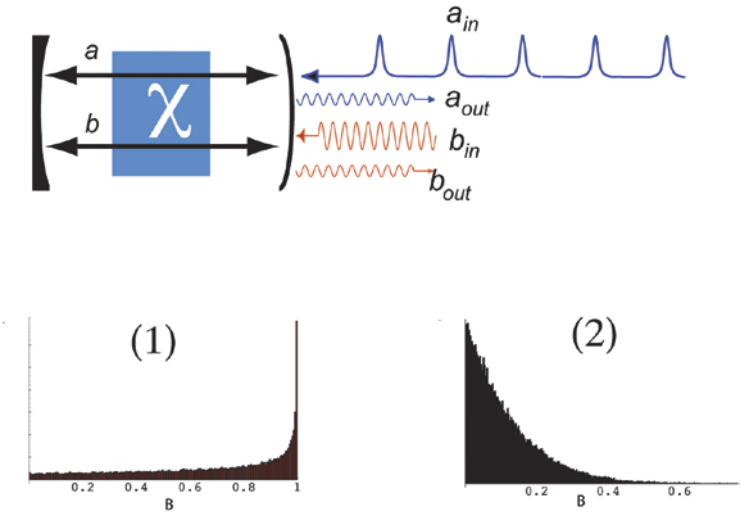

FIGURE 1

Top: A schematic representation of a pulsed single photon source interacting with a continuous coherent field via an intracavity Kerr nonlinearity. Bottom: A histogram of the changes in the amplitude of mode-b from the steady state value for many realisations of the time over which the single photon resides in the cavity for (1) cavity damping rate for mode-b is greater than the cavity damping rate for the single photon mode-a, and (2) cavity damping rate for mode-b is less than the cavity damping rate for the single photon mode-a, The number of trials is 50,000. Adapted from figure 3 of Munro et al., Optics. Comm, **283** 741 (2010).