Some studies in LOQC

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Linear Optical approach, has been a very interesting approach among several ways of achieving Quantum Computing and Metrology. Over the past decade there have been a number of theoretical methods developed towards Quantum Computing and Metrology, obviously in an extremely ideal settings. These models are needed to be investigated in more realistic sense,i.e including the effects of loss,which could be due to many factors, particularly as experiments are catching up with theory. In this direction, following is an outline of the research work carried out.

- Rapid Purification for Optical homodyning:

  This work is a direct application of rapid purification of qubits to an optical case. The process of acquiring information from a quantum system via a measurement does take finite duration of time. Usually, this is done by a set of discrete measurements, timed close enough that we can treat them essentially as a continuous measurement and the information is extracted at a finite rate. After the process the qubit gets purified in the sense that it ends up in one of the eigen states of the Hamiltonian.

  In PRA 67,030301(R)(2003) Kurt Jacobs has shown a way to increase the rate of extraction of information in a continuous measurement process using feedback. When one performs a measurement, the bloch vector tends to align along the measurement basis. The feedback is used to rotate the bloch vector perpendicular to the basis after each measurement. This increases the extracted information thereby resulting in a speedup, which is defined as the ratio of time required to purify using feedback to the time required to purify without feedback.

  We applied this procedure to the optical homodyning scheme. We consider a single mode of an optical cavity and the output light is subjected to the homodyne detection. Thus our qubit in this case is a single mode with a single photon. This is done by keeping the bloch vector aligned perpendicular to the measurement basis after each discrete measurement, so that each measurement results in maximum information extract. The feedback technique here is implemented by adjusting the phase of local oscillator. The schematic is shown below:

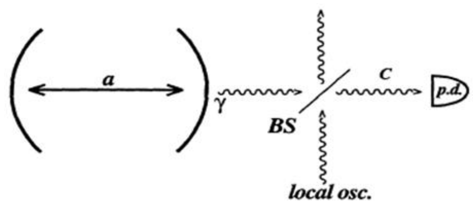

Figure 1: Schematic of the homodyning

The results have been interesting with some unexpected features in comparison with the fermionic counterpart earlier worked in the original paper by Kurt Jacobs. The evolution of purity as a function of time is shown in fig 2, which indeed explain the summary of this project.

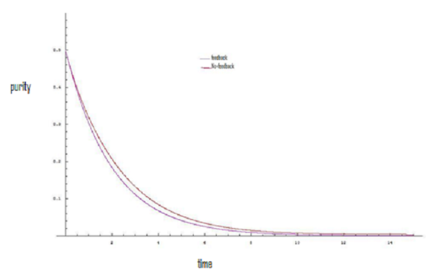

Figure 2: Evolution of Purity. Clearly feedback is faster

- Loss in Single photon approach for Heisenberg limited interferometry:

  Recently published article by Higgins et.al in Nature,450, 393-396 (2007) uses single photon states to achieve the Heisenberg limited phase estimation. This has been achieved by using a well known phase estimation algorithm, referred as Kitaev's Phase estimation algorithm in Quantum Computation. Although Kitaev's method has been known for about a decade, It required entangling C-Not gates, which are not easy to prepare in a laboratory setting. The results of Higgins et.al is very encouraging from a technological perspective as, it eliminates the need for the exotic NOON states, which are till date very difficult to prepare in the lab.

An open question in the context of interferometry is how does a method scale with Loss in one or both arms of the interferometer. Although Higgins et.al have performed an experiment, there is not any analysis of how does the method scale with Loss. It is this task we wish to perform. In this direction we are analyzing, the measurement scheme, which is done in an early paper by D.W.Berry and H.M. Wiseman (PRL(85) 24, 5098, when the interferometer is subjected to Loss in one of the arm. This is an ongoing work.

Along with the above on-going project,I am working on investigating the parity measurements with a combination of NOON state and a dual-fock state, both of them have been shown to exhibit Heisenberg limit.