Single Photon Quantum State Oscillator

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We describe a single photon quantum oscillator and show generalizations to the two and three photon cases. This structure operates by *continuously regenerating* a quantum basis state that oscillates among a subset of different basis states while also evolving a superimposed state at other points in the circuit. This basic architecture is then generalized to the case of a two- and three-qubit architecture wherein the evolved basis states oscillate, similar to the single photon case, but wherein the quantum state at other internal portions of the circuit is entangled. The motivation for the conception of these structures is to provide a means for evolving the quantum states in a deterministic and repeating fashion such that the time interval required for them to maintain coherence is minimized thus decreasing the likelihood that decoherence or unintentional observations occur. Additional motivation is to provide an architectural building block to support an quantum photonic implementation of a basis state oscillator for metrology, a true random number generator, and others.

The structure of single, double, and triple qubit oscillators is shown in Fig. 1 where either two or four linear stages are in cascade and the evolved state produced by the rightmost stage is used to excite the first stage in a continuous fashion via a "feedback" loop. We refer to the serial cascade of the stages depicted in the dashed boxes as the "feedforward" path and the lines that couple the produced quantum state of the rightmost stage to the input of the leftmost stage as the "feedback" path. The single, double, and triple photon circuits are referred to as the Quantum Ring Oscillator (QRO), Bell State Oscillator (BSO), and Greenberger-Horne-Zeilenger State Oscillator (GSO) due to the subcircuits in the feedforward paths.

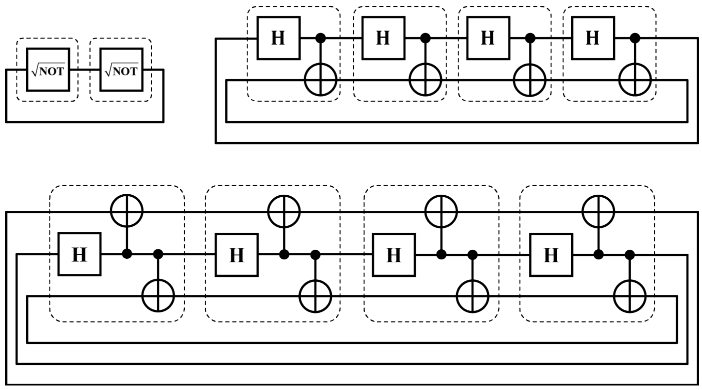

Fig 1. Quantum circuit diagrams for a) single-photon QRO, b) dual-photon BSO, and c) triple-photon GSO oscillator

In order to maintain proper operation and to avoid problems due to the accumulation of loss in the components, it is necessary to periodically inject new information carriers. Furthermore, it is necessary to include a means to observe the state of the oscillator. We exploit the fact that the quantum state at the output of the rightmost stage is a basis state which allows for the structures of Fig. 1 to be augmented with operators that provide for information carrier injection and extraction. The injection and extraction structure is shown in Fig. 2 for the case of a single qubit oscillator.

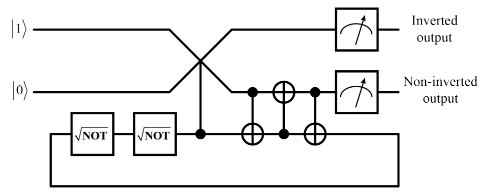

Fig 2. Single Qubit Oscillator Structure with Injection/Extraction

In addition to the obvious application of the use of these oscillators as a synchronization circuit, additional operators (and their inverses) may be added in the feedforward portion of the structure to cause intentional and arbitrary quantum states to be continuously regenerated. By coupling the Fredkin operator control point to the evolved quantum state at the output of the leftmost square-root of NOT operator in Fig. 2 (not shown), the oscillator can function as a true random qubit generator (TRNG) that continuously provides a random stream of qubit basis states due to the continuous regeneration characteristic.