PhD Candidacy Exam Proposal:

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1 A Single Photon Source Enabled by Fano Interference between a Broadband Emitter and a High Q, Kerr Cavity

Single photon sources play a prominent role in the field of quantum information science. [1, 2] In the QKD protocol, Alice encodes an information, for example, in the quibit of a photon polarization state. If Alice must securely transmit this quibit through a quantum channel to Bob, the reciever, then Alice's single photon source must be deterministic. In a case where Alice generates a probalistic two-photon state, then Eve, the eavesdropper, can glean information from one of the two photons (unbeknownst to Alice) while the second photon is transmitted to Bob. [3, 4] Moreover, since photons travel at the speed of light and interact weakly with the environment over long distances, enconding infromation in the quanutm state of a single photon (using degrees of freedom of polarization, momentum, or energy) is hihgly compatible and thus desirabble in quantum communication application.

A deterministic single-photon source that emits a single photon *on demand*, with 100 % probability, is ideal. In practice, one evaluates the single-photon nature of a source by the ratio of the probability of single-photon to multi-photon emission, and thus single-photon sources lie on a spectrum of two main classes: deterministic and probabilistic sources. [5, 6] The former involves effective two level systems (quantum dots, single atoms, single ions) [7, 8, 9, 10, 11] that emit a single photon when excited by a resonant incident field; the latter involves, for example, parametric down conversion in waveguides (or four-wave mixing in optical fiber) systems [12, 13, 14] that emit a correlated pair of photons, where one photon heralds the other. The known difficulties with these systems involve trapping of a single ion or atom strongly coupled to cavities at cryogenic temperatures for deterministic single-photon sources, and care must be taken with the probabilistic sources to avoid generating multiple pairs of photons. Herein, we propose a theoretical basis for a novel system that circumvents ion trapping at ultra-cold temperatures, and this system is operative in the Purcell regime; then we calculate the second order correlation function as a measure of its single-photon nature.

Consider the following system:

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