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A semi-classical and quantum mechanical analysis of Four-Wave-Mixing in an ensemble of Rubidium atoms

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Entangled photons are an essential ingredient in quantum information and quantum computing systems. We are currently investigating entangled photon generation via four-wave-mixing using a diamond configuration formed by four levels in Rubidium. Two pump laser beams of different wavelengths drive the atoms from a ground state |1> to an excited state |3> via an intermediate state |2>. The atoms then return to the ground state via another intermediate state |4>. The resonant interaction between the various levels results in the generation of two additional correlated photon beams referred to as idler and signal photons. The characteristics of these additional photons are studied.

As a precursor to the experimental work we perform a theoretical and computational analysis using, initially, a semi-classical model where the atom is quantized, while the photons are treated classically. Using perturbation analysis we solve for the higher order density matrix elements, from which we determine the higher order atomic polarization. This is then used in Maxwell's equations to determine the intensities of the idler and signal photons. Results of the intensities of the additional photons and the population of the various levels, as a function of detuning of the pump lasers, are presented. The analysis is then extended to include a full quantum mechanical analysis, where the photons are described by the annihilation and creation operators.

Summary

A semi-classical and quantum mechanical analysis of Four-Wave-Mixing in an ensemble of Rubidium atoms.

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