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(G*) Demonstration of a model for AFC cavity quantum memory

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Optical quantum memory that has the ability to store and on-demand, recall the quantum states of light with high efficiency and fidelity which has several applications in linear-optical quantum computation, single-photon detection, quantum metrology, tests of the foundations of quantum physics is one of the essential elements in distribution of quantum entanglement for long distance quantum communication based on quantum repeaters.
Amongst all the proposed protocols for implementation of quantum memory, atomic frequency comb (AFC) quantum memory is a promising candidate in quantum repeater applications because of the capability to store and read out multiple temporal modes that could enhance the performance of quantum repeater via faster entanglement generation. Also, opposed to other quantum memory protocols, in AFC technique the number of temporal modes that can be stored in a sample is independent of the optical depth of the storage material. To achieve high efficiency in quantum memories, large optical depth is needed. However, in practice large optical depth is difficult to gain specifically for rare-earth ion doped crystals.
To overcome this issue, it was proposed to put the memory inside an asymmetric optical cavity. By applying the impedance matching condition, unit efficiency can be obtained with an effective optical depth of one and the memory efficiency is only limited by intrinsic atomic dephasing.
So far, there have been several experiments carried out based on impedance matched proposal using atomic frequency comb technique. However, measuring the AFC properties e.g. optical depth within the cavity is formidable due to the change in cavity mode structure caused by strong dispersion effect originates from the absorption engineering of the ions to create the comb inside the cavity. As yet, there is only an estimation of the AFC structure properties e.g. optical depth inside the cavity by performing the measurements outside the cavity but the comb properties inside the cavity are not exactly known.
Here, we demonstrate a model for AFC memory inside an asymmetric cavity by broadening the scope of impedance-matched proposal which leads to better understanding of the AFC structure properties inside a cavity. We compare the results of our theory to the obtained results of the experimental data of an asymmetric cavity AFC quantum memory and we show agreement to some extent between our theory and the measurements for AFC cavity quantum memory which enables us to make predictions for comb properties i.e optically depth inside a cavity.

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