Transfer of quantum states and stationary quantum correlations in hybrid optomechanical network

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The hybrid systems like opto- or spin-mechanical, opto-electromechanical setups, etc., actually become more attractive for their effectiveness and usefulness for a wide range of quantum applications, from gravitational wave detectors to force microscopes, hence they are considered leading candidates for quantum metrology and sensing. In this context, the squeezing of the modes in a hybrid system, and particularly the squeezing transfer between them, is of major importance and applicability. The preparation of the mechanical and light modes in the squeezed states has been widely investigated theoretically, e.g. [1,2], and is nowadays experimentally feasible in versatile hybrid setups, e.g. [3,4]. In this work we study the effects of dynamical transfer and steady-state synchronization of quantum states in a hybrid optomechanical network. As an example of elemental network we consider two cavities with atoms inside and interacting via a common moving mirror, i.e. mechanical oscillator (MO), see Fig.1a. We found that when two external fields independently driving each atom (see Fig.1b), the squeezed and Schrödinger's cat states between the cavities can be transferred with an extremely high fidelity under the unitary dynamics. In this framework one observes dynamical generation and distribution of bipartite and tripartite entanglement. On the other hand, in case of highly dissipative dynamics of the hybrid optomechanical system together with the driving atoms and using a coherent pumping of squeezed phonons/photons in the initial stage, one can synchronize a pair of bosonic modes in squeezed steady states for the bipartite system as cavity 1 - cavity 2, cavity1 - MO and cavity 2 - MO. The effect of squeezing synchronization of the cavities and mechanical modes can be achieved regardless of the pump mechanism discussed here. When the two bosonic modes are synchronized in a squeezed stationary state, then these modes are also entangled.

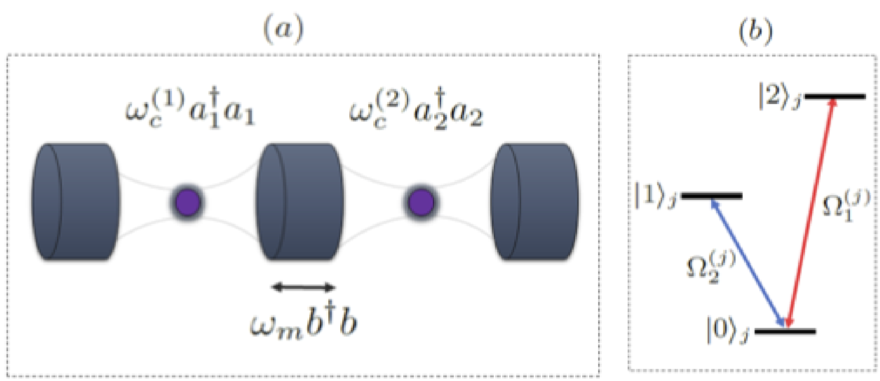

FIG. 1. (a) Schematic diagram of a cavity-atom-mechanics system. (b) Two lasers $\Omega_1^{(j)}$ and $\Omega_2^{(j)}$ are injected in the three-level j-atom, which are resonant with the transitions of the levels $|2\rangle_j \longleftrightarrow |0\rangle_j$ and $|1\rangle_j \longleftrightarrow |0\rangle_j$, respectively.

References

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