Pulsed continuous-variable optoelectromechanical transducer based on geometric phase effect

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The rapidly developing field of optomechanics provides outstanding opportunities for force, acceleration and mass detection, as well as for probing the fundamental physical effects [1]. Besides this, one promising application of the optomechanical systems is transduction between different modes of radiation enabled by the radiation pressure [2, 3].

We propose a transducer that uses a sequence of pulsed quantum nondemolition (QND) interactions of the two modes of radiation with a mechanical oscillator to effectively induce a QND coupling between the modes. The properly engineered sequence of interactions drives the mechanical oscillator around a closed path in a phase space and thereby allows to trace the mechanical mode out of the interaction of the radiation modes, leaving the latter coupled. Importantly, the coupling can be achieved regardless of the temperature of the noisy mechanical mode.

For this transducer we propose to utilize the pulsed regime of the cavity optomechanics [4, 5], when the quantum states of the modes of radiation are defined in short temporal pulses, in contrast to the conventional continuous-wave regime. Particularly we check the two physically very different regimes in which the duration of pulses is longer [6] or shorter [7] compared to the period of mechanical oscillations. We consider cases of transduction between two optical modes as well as between an optical and a microwave modes. We prove the feasibility of transducer with the parameters within experimental reach and show that the operation of transducer demonstrates high robustness to the optical loss and thermal noise of the mechanical environment.

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