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Strong quadratic and quartic optomechanical couplings for QND measurements[1]

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We describe a new class of optomechanical couplings which occur in devices consisting of a dielectric membrane placed inside an optical cavity. These couplings arise from avoided crossings in the spectrum of such a cavity, and provide a number of new functionalities to existing optomechanical devices. We show that these crossings result in purely quadratic optomechanical coupling three orders of magnitude stronger than previously demonstrated, and that optical modes with strong quadratic couplings coexist with other modes having linear coupling. In addition, we show that it is possible to realize a purely quartic optomechanical coupling. The complex cavity spectrum, including the avoided crossings, is reproduced by a straightforward theoretical model. These results are demonstrated using a stochiometric silicon nitride membrane, which for 1064 nm laser light results in an intracavity absorption more than two orders of magnitude lower than the non-stochiometric membranes used previously. We describe the possible roles these improved couplings and decreased optical loss may play in the quantum regime of optomechanical devices.

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