Frequency Shift of an Optical Cavity Mode Due to a Single Atom Motion

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The mechanical motion of a single atom influences its interaction with optical fields and gives rise a variety of mechanical optical effects [1]. The fact that the dispersion of light depends on the atomic motion has been known for over a century [2–5]. Moreover, the optical radiation itself can cause a mechanical motion via radiation pressure which has been understood for a long time and used to explain the formation of the comet’s tails. The role of radiation pressure was also understood in the last century for the early gravitational-wave detectors [6–8], and these works were pioneering the field. Recently, optomechanical effects are the focus of a broad range of research activities [9].

Using quantum coherence effects [10–13], we have developed a new technique of detection of motion of single atoms or ions in an optical cavity. We have theoretically demonstrated that the presence of single atom or ion inside cavity leads to a shift in cavity frequency and phase of transmitted probe beams. It has been shown by use of EIT technique, the change of phase is extremely sensitive to probe detuning in the vicinity of resonance frequency and can be in the order of $10^{-4}$.

References


