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Noninvasive technique for studying plasma modes of ion Coulomb crystals using cavity quantum electrodynamics

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Cavity Quantum ElectroDynamics (CQED) is a research field which focuses on understanding the interactions between matter and the electromagnetic field in cavities at the quantum level. Currently, CQED is a very active research field due to the prospect of creating efficient light-matter quantum interfaces at the single photon level for quantum information science. Ion Coulomb crystals have a series of properties of particular interest for CQED studies, as demonstrated in recent CQED experiments [1]. The coupling strength between ions in the crystals and photons in the cavity strongly depend on the motion of the ions due to the Doppler-effect. Consequently, the CQED signals can be exploited to learn about excitations of plasma modes in ion Coulomb crystals. Since the method relies on having one or less photons in the cavity at any time, it constitutes a noninvasive alternative to the Doppler-fluorescence method previous demonstrated in Penning trap experiments [2]. So far, CQED signal has been used to characterize how several normal mode frequencies depend on the aspect ratio of Coulomb crystals, and how the so-called micromotion of ions confined in rf traps influences the damping of the mode [3]. The observed mode frequencies are in remarkable agreement with theoretical prediction based on uniformly charged fluids [4].

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