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# Vibrational response of trapped ions to high-frequency gravitational waves

The detection of high-frequency gravitational waves (HFGWs) in the megahertz regime challenges conventional interferometric methods. Linear Paul traps have recently been proposed by Takai (2026) as quantum sensors for this regime. In a two-ion system, the center-of-mass mode is excited through graviton-photon conversion in the presence of a magnetic field, while the stretch mode responds directly to the gravitational tidal coupling without requiring such a field, thereby distinguishing HFGWs from axion-like dark matter.. Building on this formalism, we present a detailed step-by-step derivation of both detection channels, including resonance conditions, excitation probabilities, and expected sensitivities. Because the stretch mode is insensitive to couplings common to both ions, a null result in this channel places no constraint on such candidates; we therefore discuss how they could instead be characterized through their spectral signature in the center-of-mass mode, as a path toward positive identification in this system.

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