

Quantum entanglement of ions for light dark matter detection

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A detection scheme is explored for light dark matter, such as axion dark matter or dark photon dark matter, using a Paul ion trap system. We first demonstrate that a qubit, constructed from the ground and first excited states of vibrational modes of ions in a Paul trap, can serve as an effective sensor for weak electric fields due to its resonant excitation. As a consequence, a Paul ion trap allows us to search for weak electric fields induced by light dark matter with masses around the neV range. Furthermore, we illustrate that an entangled qubit system involving N ions can enhance the excitation rate by a factor of N^2 . The sensitivities of the Paul ion trap system to axion-photon coupling and gauge kinetic mixing can reach previously unexplored parameter space.

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