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Investigating interference with phononic bright and dark states

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Interference underpins some of the most unusual and impactful properties of both the classical and quantum worlds, from the highest powered lasers down to the level of single photons. However, with regards to light-matter coupling, neither the usual classical nor quantum descriptions of interference can sufficiently explain why some states of light couple to matter while others do not. In this work a new description of interference, based on the formation of bright and dark states, is investigated experimentally. We employ a single trapped ion, whose electronic state is coupled to two of its motional modes in order to simulate a multi-mode light-matter interaction. We observe the emergence of phononic bright and dark states for both a single phonon and a superposition of coherent states. The collective dynamics of these systems demonstrate that a description of interference based solely on bright and dark states is sufficient to explain the light-matter coupling of any initial state in both the quantum and classical regimes.

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