Coherence-Driven Topological Transition in Quantum Metamaterials

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Abstract

We introduce and theoretically demonstrate a quantum metamaterial made of dense ultracold neutral atoms loaded into an inherently defect-free artificial crystal of light, immune to well-known critical challenges inevitable in conventional solid-state platforms. We demonstrate an all-optical control, on ultrafast time scales, over the photonic topological transition of the isofrequency contour from an open to closed topology at the same frequency. This atomic lattice quantum metamaterial enables a dynamic manipulation of the decay rate branching ratio of a probe quantum emitter by more than an order of magnitude. Our proposal may lead to practically lossless, tunable, and topologically reconfigurable quantum metamaterials, for single or few-photon-level applications as varied as quantum sensing, quantum information processing, and quantum simulations using metamaterials.

Keywords

KeyWords Plus: ELECTROMAGNETICALLY INDUCED TRANSPARENCY; HYPERBOLIC METAMATERIALS; NEGATIVE REFRACTION; OPTICAL HYPERLENS; LATTICES; ATOMS; WAVE

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