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Towards switchable photon-photon interactions

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Since photons are robust carriers of information, photon-based qubits provide a promising platform for efficient error- and resource-reduced all-optical quantum computing [1,2]. When interfacing photons with matter to so-called polaritons, they additionally inherit strong particle-particle interactions [3,4]. By coupling the photons to highly-excited Rydberg states, long storage times can be achieved even in thermal vapours above room temperature [5].

We use non-interacting Rydberg polaritons to store two photons in an atomic vapour and activate the two-photon interaction on demand by driving to a second pair of strongly interacting Rydberg states. After interaction, the photons can be stored or retrieved coherently [1] from their individual polaritonic states.

We have identified a set of suitable Rydberg states in rubidium to facilitate the required interaction properties for the storage and interaction phases. Currently, the different state transitions are addressed in a thermal vapour to benchmark and optimise the em-field sources, pulsing and read-out. Here, the terahertz transition represents a particular challenge but is similarly exciting, since it extends the spectral range used for quantum simulation and computing to a yet seldom utilised but highly relevant part of the electromagnetic spectrum.

[1] PRL 127, 063604 (2021)
[2] Science 318, 1567 (2007)
[3] Nature 488, 57-60 (2012)
[4] J. Phys. B: At. Mol. Opt. Phys. 49, 152003
[5] Nature Communications 9, 2074 (2018)

Category

Other

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