From Nonlinear to Linear Control of Quantum Information and Thermodynamics

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Quantum technologies ranging from computing and communication to sensing and thermodynamic devices rely on quantum information, entanglement being its key resource. Nonlinear unitary entanglement, based on giant long-range dipole-dipole interactions (DDI), has recently been demonstrated at Weizmann to result in single-polariton entanglement [1]. This nonlinear mechanism has been shown by us to open the road to novel quantum thermodynamic devices and quantum-enhanced sensing of thermodynamic variables [2,3]. Another recent major achievement of our group concerns DDI-coupled spin networks: we have shown how quantum information processing and thermodynamics in such quantum complex networks depend on topology, symmetry constraints [4] and disorder [5].

Yet nonlinear unitary entanglement at the few-quanta level remains experimentally challenging. A straightforward substitute is based on post-selection of multipartite states [6] which incurs infidelity. A promising alternative we here propose is based on linear stroboscopic phase control that can amplify two-mode photonic entanglement to a giant degree [7].

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[2] T. Opatrny et al., Sci. Adv. 9, eadf1070 (2023)

[3] N. Meher et al., PRA 110, 013715 (2024); QST 9,045029 (2024)

[4] S. Sur et al. npj-qi (in press)

[5] P.Chattopadhyay et al., QST 10, 035006 (2025)

[6] DBR Dasari et al., Nat. Commun. 13, 7527 (2022)

[7] P. Chattopadhyay et al. (preprint)