Empowering Qudit Quantum Computing by Traversing the Dual Bosonic Ladder

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High-dimensional quantum information processing has emerged as a promising avenue to transcend hardware limitations and advance the frontiers of quantum technologies. Harnessing the untapped potential of qudits necessitates the development of quantum protocols beyond the established qubit methodologies. Here, we present a robust, hardware-efficient, and scalable approach for operating multidimensional solid-state systems using Raman-assisted two-photon interactions. We then utilize them to construct extensible multi-qubit operations, realize highly entangled multidimensional states including atomic squeezed states and Schrödinger cat states, and implement programmable entanglement distribution along a qudit array. Our work illuminates the quantum electrodynamics of strongly driven multi-qudit systems and provides the experimental foundation for the future development of high-dimensional quantum applications such as quantum sensing and fault-tolerant quantum computing.

References

[1] Nguyen*, Goss*, et al., *arXiv:2312.17741* (2023)

Figures

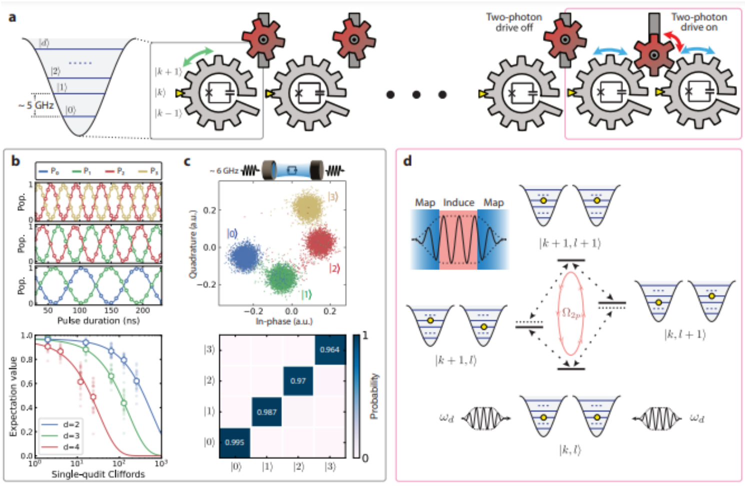

Figure 1: Overview of the experiment. Each qudit in the array is fully programmable, with single shot qudit state readout. Neighbouring qudits are entangled via a two-photon Raman process.

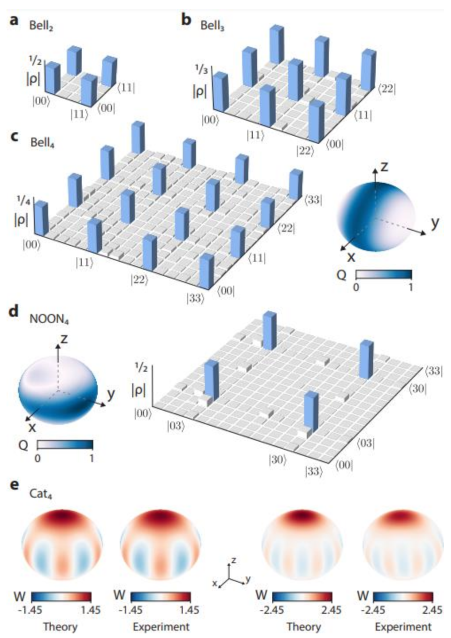

Figure 2: Experimental tomography results of high-dimensional qudit states generated by two-photon Raman entanglement.