Hypercubes, drums, and single photons

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Massive systems in the quantum regime offer significant potential for the development of powerful new quantum-enhanced technologies—such as ultra-precise sensors and new types of transducers—and for quantum foundations—by observing how quantum superpositions behave at a large scale.

We adapted a trick from optical quantum computing to help us play a quantum drum: introducing an optomechanical scheme that can prepare non-Gaussian quantum states of motion of a mechanical resonator using photonic quantum measurements. Our method is capable of generating nonclassical mechanical states without the need for strong single-photon coupling, is resilient against optical loss, and offers more favourable scaling against initial mechanical thermal occupation than existing schemes.

We introduce—and show how to generate—hypercube states, a class of quantum states with sub-Planck phase-space features that reduce in size with the order of the state. The two lowest-order members of the class are the well-known Schrödinger-cat state and the more recently introduced compass state. We explore the measurement precision and sensitivity of these states to sub-Planck perturbations in different regimes of temperature and optical coupling, finding that their sensitivity is surprisingly robust. We also experimentally observe the characteristic signature of these states in the high temperature regime.