中央大學物理學系

Department of Physics, National Central University

Colloquium

Quantum Technologies with Infinite-Dimensional Quantum Systems

Prof. Chiao-Hsuan Wang (王喬萱)

Dept. of Physics, NTU台灣大學物理學系

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Abstract

Advents in fabricating high-quality-factor photonic and phononic cavities have led to increasing interest in quantum computation with bosonic systems. In contrast to traditional methods of encoding quantum information in multi-qubit systems, efforts in bosonic quantum computation exploit the infinite-dimensional Hilbert space of a quantum harmonic oscillator to process and transmit quantum information in a hardware-efficient way. I will present a scheme to engineer a target Hamiltonian for photonic cavities using ancilla qubits. By off-resonantly driving dispersively-coupled ancilla qubits, we develop an optimized approach to engineering an arbitrary photon-number dependent (PND) Hamiltonian for the cavities while minimizing the operation errors. The engineered Hamiltonian admits various applications, including canceling unwanted cavity self-Kerr interactions, creating higher-order nonlinearities for quantum simulations, and designing single- and two-cavity gates resilient to noise. Our scheme can be implemented with coupled microwave cavities and transmon qubits in superconducting circuit systems. This work paves the way for near-term applications of noisy intermediate-scale quantum devices and the long-term goal of fault-tolerant quantum computations.