Networks of Optical Parametric Oscillators: From Ising Machines to Quantum Photonic Engineering

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In the past few years, networks of optical parametric oscillators (OPOs) have been successfully used to simulate the classical Ising Hamiltonian leading to a platform that may be used as a special-purpose computer. In this talk, we will overview the fundamental properties of OPOs at degeneracy that enable simulation of the Ising Hamiltonian [1, 2, 3]. We will discuss the concept of time-multiplexed OPO networks [4], which in combination with the measurement-feedback architecture, has led to a special implementation of large-scale Ising machines [5, 6] that are being studied extensively [7]. We will also overview the potentials of OPO networks in realization of a wide range of quantum states, from the well-known squeezed vacuum and multi-mode entangled states [8] to less-explored highly-desired Cat states [9] and present a potential path toward scalable quantum photonic engineering using them. We will discuss recent numerical studies of ultra-short pulse OPOs in the highly-nonlinear quantum regime [10] and present some of the practical benefits and challenges associated with using them as the building block of a quantum photonic platform.