

Quantum Advantage with Photons and Beyond

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The main challenge for scaling up photonic quantum technologies is the lack of perfect quantum light sources. We have pushed the parametric down-conversion to its physical limit and produce two-photon source with simultaneously a collection efficiency of 97% and an indistinguishability of 96% between independent photons. Using a single quantum dot in microcavities, we have produced on-demand single photons with high purity (>99%), near-unity indistinguishability, and high extraction efficiency – all combined in a single device compatibly and simultaneously. Based on the high-performance quantum light sources, we have implemented boson sampling—which is an intermediate model of quantum computing, a strong candidate for demonstrating quantum computational advantage and refuting Extended Church Turing Thesis – with up to 113 photon clicks after a 144-mode interferometer. The photonic quantum computer, Jiuzhang, yields an output state space dimension of 10^{43} and a sampling rate that is 10^{24} faster using the state-of-the-art simulation strategy on supercomputers.