Experimental boson sampling

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The extended Church-Turing thesis posits that any computable function can be calculated efficiently by a probabilistic Turing machine. If this thesis held true, the global effort to build quantum computers might ultimately be unnecessary. The thesis would however be strongly contradicted by a physical device that efficiently performs a task believed to be intractable for classical computers. BosonSampling—the sampling from a distribution of n photons undergoing some linear-optical process—is a recently developed, and experimentally accessible example of such a task [1].

Here we report an experimental verification of one key assumption of BosonSampling: that multi-photon interference amplitudes are given by the permanents of submatrices of a larger unitary describing the photonic circuit. We built a tunable photonic circuit consisting of a central 3x3 fiber beamsplitter, and exploited orthogonal polarization modes to extend the network to 6x6 modes. We developed a direct characterization method [2] to obtain the unitary description of this network and compared theoretical interference patterns predicted from this unitary with an experimental signature obtained via non-classical interference of three single photons [3]. Our results show good agreement with theory, and we can rule out an explanation of the observed interference via classical means. We conclude that small-scale BosonSampling can be performed in the presence of unavoidable optical loss, imperfect photon sources, and inefficient detection [3].

[1] S. Aaronson and A. Arkhipov, Proceedings of the ACM Symposium on Theory of Computing, San Jose, CA pp. 333–342 (2011).

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[3] M. A. Broome, A. Fedrizzi, S. Rahimi-Keshari, J. Dove, S. Aaronson, T. C. Ralph, and A. G. White, Science 339 (2013).