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# Quantum information processing with linear-optical networks

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**Abstract**

In this talk, I will present some recent results on boson sampling that is an intermediate model of quantum computation. This model seeks to generate random samples from a probability distribution of photon (or, in general, boson) counting events at the output of an M-mode linear-optical network consisting of passive optical elements for N input single photons [1]. There is great interest in this particular computational problem as this task, despite its simple physical implementation, is strongly believed to be a problem that cannot be efficiently simulated using classical computers. In this presentation, we show that using parametric down-conversion sources one can, in principle, implement randomized version of boson sampling that is classically intractable as well [2]. Then for the case of thermal state inputs, we show that an efficient classical sampling algorithm exists based on the realization of thermal states by a distribution over coherent states. Considering this case, we have obtained a new result that is of interest from the computational complexity theory point of view [3]. I further discuss a general sufficient condition for efficient classical simulation of quantum optics experiments and its application for physical implementations of boson sampling. We show that above some threshold for loss and noise in the experiment, boson sampling is classically simulatable.

## References

[1] S. Aaronson and A. Arkhipov, Theory of Computing 9, 143 (2013).

[2] Austin P. Lund, Antony Liang, Saleh Rahimi-Keshari, Terry Rudolph, Jeremy L. OBrien, and Timothy C. Ralph, Boson Sampling from a Gaussian state, Physical Review Letters 113, 100502 (2014).

[3] Saleh Rahimi-Keshari, Austin P. Lund, and Timothy C. Ralph, What can quantum optics say about computational complexity theory? Physical Review Letters 114, 060501 (2015).