It is generally believed that quantum computers can perform certain tasks faster than their classical counterparts. Identifying the resource that potentially enables this speedup is of particular interest in quantum information science, both from theoretical and practical perspectives. Attempts to identify the elusive quantum feature are generally back-door attacks, studying not what is essential for speedup, but rather what is lacking in quantum circuits that can be efficiently simulated classically.

In this talk, by using the well-developed theory of phase-space quasiprobability distributions, I introduce sufficient conditions for efficient classical simulation of generic quantum-optics experiments [1]. These conditions show that negativity in the quasiprobability distributions is an essential resource for a generic experiment not to be efficiently simulatable. Moreover, I discuss that these conditions provide useful practical tools for investigating the effects of imperfections in implementations of quantum protocols, in particular, boson sampling that is believed to be a classically hard problem [2].

[1] S. Rahimi-Keshari, T. C. Ralph, and C. M. Caves, Phys. Rev X 6, 021039 (2016).

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