



INVITATION

to a **TALK** by

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Quantum Simulation of Complex Physical Hamiltonians using Directionally Unbiased Linear-Optical Multiports

The rapidly expanding research activity on quantum computing is ultimately an outgrowth of the profound Feynman's observation that only quantum systems are capable to efficiently simulate other quantum systems [1]. The goal of quantum simulation is therefore to find simple quantum systems that can accurately and efficiently simulate specific properties of interest in more complex quantum physical entities. The approaches used up to now for quantum simulations of nontrivial physical systems have substantial limitations. For example, working with cold atoms or superconducting qubits requires extremely low temperatures in order to avoid decoherence. This adds numerous complications to the experiments and makes this approach unlikely to be useful outside of research laboratories. On the other hand, analogous simulations done with traditional optical quantum walks have their own complications. In particular, they require a set of optical resources (beam splitters, mirrors, etc.) that grows rapidly with the number of steps in the walk. These factors strongly limit the ability to use the current optical approaches for practical simulations on a large scale, and so it is of interest to investigate schemes that may be more easily scalable.

Recently, a novel linear optical multiport was proposed [2] which allows photons to reverse direction, thus transcending feed-forward linear optics by providing a linear-optical scattering vertex for quantum walks on arbitrary graph structures. It is currently practical to carry out a table-top version of our new procedure, and in the near future it should be plausible to implement it on much larger scales by integrating all of the required optical elements onto optical chips that can be fabricated in large numbers and arranged into the desired configurations with high stability. A quantum walk using arrays of such multiports allows simulating a broad range of discrete-time Hamiltonian systems including cases where physical systems with both spatial and internal degrees of freedom [3] as well as topological states are simulated [4]. Because input ports also double as output ports, there is substantial savings of resources compared to traditional feed-forward quantum walk networks carrying out similar functions. The simulation is implemented using only linear optics. Furthermore, this scheme has the advantage that the parameters of the underlying system on which the walk occurs can be readily varied to produce a variety of simulated behaviors.

Refs:

- [1] R. P. Feynman, "Simulating physics with computers", Int. J. Theor. Phys. 21, 467 (1982).
- [2] D. S. Simon, C. A. Fitzpatrick, and A. V. Sergienko, "Group Transformations and Entangled-State Quantum Gates With Directionally-Unbiased Linear-Optical Multiports," Phys. Rev. A 93, 043845 (2016).
- [3] D. S. Simon, C. A. Fitzpatrick, S. Osawa and Alexander V. Sergienko, "Quantum Simulation of Discrete-Time Hamiltonians Using Directionally-Unbiased Linear Optical Multiports," Phys. Rev. A 95, 042109 (2017).
- [4] D. S. Simon, C. A. Fitzpatrick, S. Osawa and Alexander V. Sergienko, "Quantum Simulation of Topologically Protected States Using Directionally Unbiased Linear-Optical Multiports", Physical Review A v. 96, 013858 (2017).

Thursday, November 16th, 2017
14:00 s.t.

IQOQI Seminar room, 2nd floor
Boltzmannngasse 3, 1090 Vienna

Hosted by: Anton Zeilinger