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Simulation of wave-packet dynamics in cyclic quantum systems by means of single photons

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Abstract

A proper understanding of many phenomena in condensed matter physics is through examining their topological effects. In recent years, exploiting quantum simulators in studying topological properties of simple periodic systems (such as one- and two- dimensional) via invoking single photons has received numerous interests. These photonics quantum simulators are potentially useful in describing the physical properties emerging from the dynamics of electrons in periodic structures and can also be used in designing novel quantum computational systems. In this aspect, generalizing these simulators to consider closed geometries such as ring-shaped structures can lead to a broader range of simulating quantum mechanical phenomena in physics and chemistry. For instance, in aromatic molecules such as benzene or ozone, the transport properties and preferred bond formation is well-understood based on the specific spatial and spin distributions of their valence electrons. Classical simulators are not efficient in describing the mechanisms governing the

underlying dynamics and physics of such systems. In this work, we propose a theoretical and experimental model based on the discrete time quantum walk of single photons on a cyclic structure

composed of a finite number of identical sites. In particular, we simulate electron wave-packet dynamics under different initial conditions and different quantum walk gates for a six-sited geometry, namely simulating a benzene-like structure. We examine charge transport and charge localization, as well as the energy dispersion and group velocity relations in cyclic systems with our photonic quantum simulator.

Biography:

Dr. Farshad Nejadsattari completed his PhD in solid state physics at the University of Ottawa in 2016. He continued his studies as a postdoc in professor Stadnik's group where his research focused on theoretical and experimental studies of electronic structure and magnetic properties of novel compounds. He currently is a postdoctoral fellow in professor Ebrahim Karimi's structured quantum optics group. During his research he developed experimental and theoretical methods of simulating dynamics of simple solid state systmes using the properties of single photons. Dr. Nejadsattari has over 15 publications in peer reviewed scientific journals and also a number of conference proceeding.

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