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Referee's report on the PhD dissertation by

Ing. Jan MAREŠ

"Dynamics of percolated quantum walks on graphs"

submitted for defense to the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague

The topic of the thesis by Jan Mareš is the detailed theoretical analysis of a specific quantum walk model, where the underlying graph is changing in time according to a dynamic percolation rule. Quantum walk models have recieved much interest in the past few years, first because of their importance as an algorithmic tool in quantum information and second because they model transport phenomena in a conceptually simple way. A third aspect that I would like to stress, is the fundamental importance of this model as a special open quantum system for which one can find analytic asymptotic solutions.

The dissertation contains a concise introduction to coined quantum walks, the related percolation problem and their application to study quantum transport with a well-defined sink (Chapter 1). The author uses a slightly modified definition of a coined quantum walk by using directed graphs instead of the usual undirected underlying graph. I find this definition logical and very useful for the purpose of treating walks on percolation graphs. In the next part (Chapter 2) the generic method to find the asymptotic evolution is summarized. This is based on earlier results, but the author could slightly extend the known results.

The main general results of the thesis are presented in Chapter 3, where Grover walks on 3-regular graphs are considered. The author concentrates here on a systematic analysis of the possible cases and finds solutions as generally as possible for all interesting Grover coins (reflecting, cyclic, lazy), then specifies the results for some chosen graphs. In the last part of the thesis (Chapter 4), based on the general results, the author analyses transport on particular graphs. The examples of the linear and ladder graphs already feature some counterintuitive effects: the transport efficiency may grow with the length of the structure. The third example follows the graph structure of carbon nanotubes. The previously found phenomenon of increasing transport efficiency with increasing length is also present here. The last considered example graph is the Cayley tree. In this case, the asymptotic transport probability is affected by the graph structure in a non-trivial way. Even though the graph grows exponentially with the distance from the center, we still recover the length-increasing nature of transport here

Another surprising effect is that cutting certain, seemingly unnecessary branches, the transport probability diminishes. All these effects are clearly explained by the author supported by analytic results.

In summary, the thesis is clearly written in a good scientific style, I did not find errors. A large part of the presented results have been published in high quality scientific journals (2 articles in Phys. Rev. A and 1 in Phys. Lett. A; Jan Mareš is the first author in all 3 publications). In my opinion, the author achieved interesting and important results and considerably improved our understanding of how percolation affects transport in the quantum walk model. Therefore I recommend the dissertation for defense without hesitation.

Tamás Kiss