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Simulating the same dynamics with different local Hamiltonians

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The interest in developing solid theoretical frameworks to describe analog quantum simulation arises from the diverse range of potential applications it offers in areas such as condensed-matter physics, high-energy physics or quantum chemistry, in an era where fully fault-tolerant operations have not yet taken over NISQ (noisy,
intermediate scale, quantum) devices. One of my previous work has shown that two different Hamiltonians can produce the same dynamics and revealed when they can [1]. Particularly, we considered different ranges of interactions such as next neighbouring interactions and infinite range interactions. Now, we focus on Hamiltonians that have different locality and study when they can produce the same dynamics [2]. First, we discuss exact simulation and shows that even noncommuting Hamiltonians could share some of their eigenvectors and in the shared subspace the exact simulation is doable. Second, we allow for some error and discuss the relation between the simulation error at worst and locality. In this work, we acknowledge the need to search for a simulator Hamiltonian that is more local than the target one, in light of the pressing difficulty of realising many-body interactions experimentally.

[1] K. Gietka, A. Usui, J. Deng, and Th. Busch, Phys. Rev. Lett. 126, 160402 (2021)
[2] A. Usui, M. García Díaz, and A. Sanpera, in preparation.

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