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Searching for Majorana Zero Modes Using Model-free Reinforcement Learning

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Majorana fermions are particles which are their own antiparticles; hence they have zero charge. They are governed by non-Abelian statistics. For a Majorana fermionic operator γ , and the Hamiltonian of a system H , Majorana fermions satisfy fermionic anti-commutation relation (that is, for a pair of Majorana operators γ_i , γ_j ; $\{\gamma_i, \gamma_j\} = 2\delta_{ij}$) and a Majorana fermion squares to 1 (that is, $\gamma^2 = 1$). If, in addition to this, the fermionic operator commutes with the Hamiltonian of the system (that is, $[H, \gamma] = 0$), then such an operator is a Majorana zero mode (MZM). Majorana zero modes are Majorana fermions bound to zero energy. MZMs have applications in both topological quantum computation and spintronics. However, Majorana zero modes are yet to be conclusively demonstrated experimentally. In this work, we report the algorithm that searches for MZMs using reinforcement learning. Reinforcement learning is a machine learning paradigm where the learner is a decision-maker (agent) that takes action in an environment and receives rewards or penalties for the actions taken. Results obtained from this work demonstrate the significance of using reinforcement learning in the quest for Majorana zero modes.

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