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Towards Real-Time Simulation of Sphaleron Dynamics at Colliders

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Sphaleron production in the Standard Model at high-energy particle collisions remains experimentally unobserved, with theoretical predictions hindered by its nonperturbative real-time nature. In this work, we investigate a quantum simulation approach to this challenge. Taking the $1+1$D $O(3)$ model as a protocol towards studying dynamics of sphaleron in the electroweak theory, we identify the sphaleron configuration and establish lattice parameters that reproduce continuum sphaleron energies with controlled precision. We then develop quantum algorithms to simulate sphaleron evolutions where quantum effects can be included. This work lays the ground to establish quantum simulations for studying the interaction between classical topological objects and particles in the quantum field theory that are usually inaccessible to classical methods and computations.

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