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Repulsively Bound Hadrons in a Z_2 Lattice Gauge Theory

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Sayak Guha Roy is a fourth-year Ph.D. candidate in the Department of Physics and Astronomy at Rice University, working under the supervision of Prof. Kaden Hazzard. He is interested in quantum many-body theory and quantum information theory, with his current research focusing on, among other things, time dynamics of lattice gauge theory models. He is very drawn towards numerical simulation techniques, with a recent focus on tensor network methods. Prior to this, he worked with Prof Kevin Slagle on the development of a new tensor-network-based time evolution technique, rTEBD, and on approaches that interpolate between the gauge and Schrödinger pictures of quantum dynamics. He received his bachelor's and master's degrees in Physics from the Indian Institute of Technology Madras, Chennai, India.

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ABSTRACT

Abstract: Lattice gauge theory models are being extensively studied to gain insights into both particle physics and condensed matter physics phenomena. Recently, simple toy models such as a Z_2 lattice gauge theory have been experimentally realized in quantum simulators. The Z_2 gauge theory model exhibits QCD-like confinement mediated by the gauge field that binds pairs of particles into mesons. In the absence of any additional attractive interactions among particles, the mesons are not known to bind in this model. Here we argue that there is an additional repulsive binding mechanism that forms a stable bound state of two mesons, which we generally term as hadrons. Repulsive bound states are high energy states that are stabilized by being off-resonantly coupled to a continuum. We show that resonant pair production terms in this model stabilize a repulsively bound hadronic state composed of two mesons. We study the dynamical formation of this bound state starting from local excitations. We use a Matrix Product State based Time Evolving Block Decimation algorithm to perform our numerical simulations and analyze the effect of model parameters on the bound state formation. We also derive an effective model that explains the formation of this bound state.

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