RICE QUANTUM GROUP MEETING SEMINAR SERIES

Adiabatic Ground State Preparation for an Interacting Synthetic Dimension System

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Joseph Desroches is a second-year Ph.D. student in the Physics and Astronomy Department at Rice University, working under the supervision of Prof. Kaden Hazzard. Joseph is primarily interested in simulating quantum many-body physics using both classical algorithms and quantum platforms, including both digital quantum computers and analog quantum simulators. His current research, in part, focuses on preparing and investigating special quantum states in different AMO platforms, including ground states of novel quantum phases in a Rydberg-atom-based synthetic dimension system.

Before coming to Rice, Joseph earned his B.S. in Physics and Mathematics at Northeastern University, where he worked with Prof. Sijia Dong on developing new methods to simulate quantum chemistry using quantum annealing devices. He also gained industry experience through AMO-focused co-ops at Commonwealth Fusion Systems and Specter Aerospace.

ABSTRACT

Synthetic dimensions provide a powerful framework for engineering and exploring quantum many-body physics through the reinterpretation of the internal states of atoms/molecules as extra spatial degrees of freedom. Here, we investigate adiabatic ground state preparation of synthetic dimension systems constructed from the internal states of ultracold molecules or Rydberg atoms. Specifically, we focus on realizing an interacting 2D synthetic dimension system with a 1D chain of ultracold molecules or Rydberg atoms, where effective tunneling between synthetic sites is controlled by highly tunable microwave fields and dipolar interactions connect neighboring lattice sites. By numerically simulating adiabatic state preparation, we explore optimal ramp protocols that maximize ground state fidelity and suppress diabatic excitations. Our results provide experimentally realistic protocols to prepare ground states with high fidelity in interacting synthetic dimensions, paving the way for the experimental investigation of ground state properties of synthetic dimension systems and novel quantum string phases.

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