Non-abelian string-breaking dynamics on a qudit quantum computer

Manuel John

University of Innsbruck, Technikerstraße 25a, Innsbruck 6020, Austria

The Standard Model of particle physics underpins our understanding of fundamental interactions by describing the interplay of matter and forces through gauge theories. Yet, despite their huge success in studying a wide range of phenomena, the intrinsic quantum nature of gauge theories renders certain problems notoriously difficult to study. Particularly, real-time dynamics remain largely inaccessible to high-energy experiments and classical simulations. While quantum computers and simulators have recently made great progress in the simulation of abelian dynamics, more complex non-abelian theories, such as quantum chromodynamics, have proven to be extremely challenging. Here we demonstrate the use of a trapped-ion qudit quantum processor to study non-abelian string-breaking dynamics in a truncated SU(2) model. We experimentally demonstrate the coherent evolution of strings prepared in unbreakable configurations—leading to string oscillations, as well as breakable configurations—leading to gluonic (glueball) excitations. This highlights the potential of hardware-efficient and problem-tailored qudit quantum simulations for the field of high-energy physics.