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SU(2) hadrons on a quantum computer

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We realize, for the first time, a non-Abelian gauge theory with both gauge and matter fields on a quantum computer. This enables the observation of hadrons and the calculation of their associated masses. The SU(2) gauge group considered here represents an important first step towards ultimately studying quantum chromodynamics, the theory that describes the properties of protons, neutrons and other hadrons. Quantum computers are able to create important new opportunities for ongoing essential research on gauge theories by providing simulations that are unattainable on classical computers. Our calculations on an IBM superconducting platform utilize a variational quantum eigensolver to study both meson and baryon states, hadrons which have never been seen in a non-Abelian simulation on a quantum computer. We develop a resource-efficient approach that not only allows the implementation of a full SU(2) gauge theory on present-day quantum hardware, but further lays out the premises for future quantum simulations that will address currently unanswered questions in particle and nuclear physics.

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