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Experimental photonic quantum simulation of frustrated Heisenberg spins PHILIP WALTHER, University of Vienna, XIAO-SONG MA, Austrian Academy of Sciences, BORIVOJE DAKIC, University of VIenna, WILLIAM NAYLOR, ANTON ZEILINGER, Austrian Academy of Sciences — Quantum simulators are controllable quantum systems that can reproduce the dynamics of the system of interest, which are typically unfeasible for classical computers. The recent developments of quantum technology enable the precise control of individual quantum particles as required for studying complex quantum systems. In particular, quantum simulators capable of simulating frustrated Heisenberg spin systems provide a platform for understanding exotic matter such as high-temperature superconductors. Here we report the analog quantum simulation of arbitrary Heisenberg-type interactions among four spin-1/2 particles. This spin-1/2 tetramer is the two-dimensional archetype system whose ground state belongs to the class of valence-bond states. Depending on the interaction strength, frustration within the system emerges such that the ground state evolves from a localized to a resonating valence-bond state. This spin-1/2 tetramer is created using the polarization states of four photons. The precise single-particle addressability and a tunable measurement-induced interaction allows us to obtain fundamental insights into entanglement dynamics among individual particles by observing the frustration of entanglement, governed by quantum monogamy.

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