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Entangling spin-spin interactions of ions in individually controlled potential wells[1] ANDREW WILSON, YVES COLOMBE, KENTON BROWN, EMANUEL KNILL, DIETRICH LEIBFRIED, DAVID WINELAND, NIST — Physical systems that cannot be modeled with classical computers appear in many different branches of science, including condensed-matter physics, statistical mechanics, high-energy physics, atomic physics and quantum chemistry. Despite impressive progress on the control and manipulation of various quantum systems, implementation of scalable devices for quantum simulation remains a formidable challenge. As one approach to scalability in simulation, here we demonstrate an elementary building-block of a configurable quantum simulator based on atomic ions. Two ions are trapped in separate potential wells that can individually be tailored to emulate a number of different spin-spin couplings mediated by the ions' Coulomb interaction together with classical laser and microwave fields. We demonstrate deterministic tuning of this interaction by independent control of the local wells and emulate a particular spin-spin interaction to entangle the internal states of the two ions with 0.81(2) fidelity. Extension of the building-block demonstrated here to a 2D-network, which ion-trap micro-fabrication processes enable, may provide a new quantum simulator architecture with broad flexibility in designing and scaling the arrangement of ions and their mutual interactions.

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