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Strongly interacting photons in a synthetic magnetic field

PEDRAM ROUSHAN, Google, Inc., C. NEILL, UCSB, A. MEGRANT, Y. CHEN, R. BARENDS, Google, Inc., B. CAMBELL, Z. CHEN, B. CHIARO, A. DUNSWORTH, UCSB, A. FOWLER, E. JEFFREY, J. KELLY, E. LUCERO, J. MUTUS, Google, Inc., P. O'MALLEY, UCSB, M. NEELEY, C. QUINTANA, D. SANK, Google, Inc., A. VAINSENCHER, J. WENNER, UCSB, T. WHITE, Google, Inc., E. KAPIT, Tulane University, J. MARTINIS, Google, Inc. — Interacting electrons in the presence of magnetic fields exhibit some of the most fascinating phases in condensed matter systems. Realizing these phases in an engineered platform could provide deeper insight into their. Using three superconducting qubits, we synthesize artificial magnetic fields by modulating the inter-qubit coupling. In the closed loop formed by the qubits, we observe the directional circulation of a microwave photon as well as chiral groundstate currents, the signatures of broken time-reversal symmetry. The existence of strong interactions in our system is seen via the creation of photon vacancies, or "holes", which circulate in the opposite direction from the photons. Our work demonstrates an experimental approach for engineering quantum phases of strongly interacting bosons.

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