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Broken selection rule in the quantum Rabi model GUILLERMO ROMERO, University of Santiago of Chile, POL FORN-DÍAZ¹, University of Waterloo, C. J. P. M HARMANS, TU Delft, ENRIQUE SOLANO, University of the Basque Country, HANS MOOIJ, TU Delft — We report the spectroscopic observation of a resonant transition that breaks a selection rule in the quantum Rabi model, implemented using an *LC* resonator and a superconducting qubit. The eigenstates of the system consist of a superposition of bare qubit-oscillator states with a relative sign. In the limit of low qubit-oscillator coupling strength, the matrix element between excited eigenstates of different sign is very small in presence of an oscillator drive, establishing a sign-preserving selection rule. Here, our qubit-resonator system operates in the ultrastrong coupling regime, where the coupling strength is 10% of the resonator frequency, allowing sign-changing transitions to be activated and, therefore, detected. This work shows that sign-changing transitions are an unambiguous, distinctive signature of systems operating in the ultrastrong coupling regime of the quantum Rabi model. These results pave the way to further studies of sign-preserving selection rules in multiqubit and multiphoton models.

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