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**Engineering the parity of light-matter interaction in superconducting circuits**[1] J. GOETZ, F. DEPPE, P. EDER, M. FISCHER, S. POGORZALEK, E. XIE, K.G. FEDOROV, A. MARX, R. GROSS, Walther-Meissner-Institut, TU Muenchen, Nanosystems Initiative Munich (NIM) — In physics, parity describes intrinsic symmetries of quantum states and operators, which has manifold applications in the standard model, quantum information and field theory. The latter includes quantum electrodynamics, describing light-matter interaction predominantly with the odd-parity dipole operator because even-parity quadrupole interactions are strongly suppressed. We present a novel technique for the in-situ transformation of the interaction parity in superconducting quantum circuits. By coupling the odd Pauli operator $\sigma_x$ to the quadrupole moment and the even operator $\sigma_z$ to the dipole moment of a flux qubit, we can precisely engineer the interaction parity with spatially shaped microwave fields. Our highly symmetric sample architecture enables a complete parity inversion and the observation of longitudinal-coupling-induced transparency. By additional engineering the parity of participating quantum states, we can activate quadrupolar transitions similar to those in multielectron atoms. Our work paves the way towards parity based quantum simulation and physical applications based on longitudinal light-matter interaction.

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Jan Goetz
Walther Meissner Institut

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