Nonreciprocal reconfigurable microwave optomechanical circuit

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Nonreciprocal devices such as isolators, circulators, and directional amplifiers are pivotal to quantum signal processing with superconducting circuits. In the microwave domain, commercially available nonreciprocal devices are based on ferrite materials. These devices pose significant compromises when used with superconducting quantum circuits, as they are bulky, lossy, and cannot be integrated on chip. Significant potential exists for implementing non-magnetic chip-scale nonreciprocal devices using microwave optomechanics in which the modes of a superconducting circuit is coupled to the modes of a mechanically compliant capacitor. Here we demonstrate nonreciprocal frequency conversion in a multimode microwave optomechanical circuit using solely optomechanical interaction between the modes. We achieve isolation of over 20 dB whose direction can be dynamically controlled with the phase of the pumps. We discuss the role of the mechanical dissipation, the noise performance of the device and a proof-of-principle of extending the device functionality with low-noise (directional) amplification. These results show that optomechanical circuits can pave the way towards on-chip integrated non-reciprocal devices for quantum signal processing.