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### **Circulation and Directional Amplification in the Josephson Parametric Converter**

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Nonreciprocal transport and directional amplification of weak microwave signals are fundamental ingredients in performing efficient measurements of quantum states of flying microwave light. This challenge has been partly met, as quantum-limited amplification is now regularly achieved with parametrically-driven, Josephson-junction based superconducting circuits. However, these devices are typically non-directional, requiring external circulators to separate incoming and outgoing signals. Recently this limitation has been overcome by several proposals and experimental realizations of both directional amplifiers and circulators based on interference between several parametric processes in a single device. This new class of multi-parametrically driven devices holds the promise of achieving a variety of desirable characteristics simultaneously— directionality, reduced gain-bandwidth constraints and quantum-limited added noise, and are good candidates for on-chip integration with other superconducting circuits such as qubits.