Superconducting parametric devices for quantum information processing.

Leonardo Ranzani, Kin Chung Fong, Thomas A. Ohki
Raytheon BBN Technologies, Cambridge, Massachusetts 02138, USA

Superconducting quantum circuits exploit the laws of quantum physics to solve computationally hard problems exponentially faster than classical computers. In order to readout the state of a quantum bit (or qubit) with high fidelity, the quantum circuit needs to be probed by external, weak coherent signals. To amplify such small signals, low-noise parametric amplifiers that can approach the standard quantum limit, i.e. the minimum noise level allowed by quantum mechanics, are usually employed.
In superconducting parametric amplifiers, gain is obtained by modulating a nonlinear inductive element with a strong microwave pump, so that energy is converted from the pump to a signal and idler waves. The nonlinear inductance is typically implemented using high kinetic inductance materials or Josephson junctions organized in either a traveling-wave or lumped-element geometry. Due to their purely reactive nature, parametric amplifier have low dissipation and can therefore operate close to sensitive superconducting quantum circuits.

In this talk we are going to discuss our recent progress in the development and characterization of superconducting parametric devices. In particular we will discuss a low-noise traveling-wave kinetic inductance amplifier having more than 4 GHz bandwidth and up to 15 dB gain. Amplification is obtained by launching a microwave pump and signal into a meandered superconducting TiN coplanar waveguide whose dispersion properties have been engineered to achieve phase matching between the signal and the pump and maximize gain and bandwidth. We characterized the amplifier gain and noise performance in a low-temperature (T~18 mK) two-port microwave calibration system. We will also discuss how parametric interactions can be exploited to build reconfigurable low-noise nonreciprocal microwave circuits.