Coulomb Blockade of Josephson junction: Non-Classical Radiation

O. Parlavecchio, Max Hofheinz, C. Altimiras, P. Joyez, D. Vion, P. Bertet, P. Roche, D. Esteve & F. Portier
Service de Physique de l’Etat Condensé (CNRS URA 2464), CEA Saclay, France

field: mesoscopic physics, circuit quantum electrodynamics, quantum microwaves

Abstract

When a quantum conductor (here a tunnel junction) is connected to a high-impedance environment, electrons are coupled to electromagnetic modes and energy transfers (inelastic conduction processes) can occur. For a Josephson junction this results in a sub-gap dc-current a finite voltage. We designed an experiment that collects the microwave radiation associated to inelastic tunneling process. In the case the electromagnetic environment is made of two modes at different frequencies, it is possible to produce pairs of photons at different frequencies. This corresponds to a non-classical radiation that violates the Cauchy-Schwarz inequality. This is what we have investigated experimentally.

General

Two-mode environment
(Non-Classical Radiation)

Circuit

Shot Noise Calibration

Mean Rates
(pertusive $E_0$, T=0 K)

N-photon process:

Correlations at $2\nu = \nu + \nu$ vs

Coulomb Blockade Map

HBT Correlations

Non-Classical Radiation

Perspectives

Higher rates: from incoherent to coherent tunneling of Cooper pairs

Experimental Setup

Results

Conclusion

quantitative agreement for the 1-photon process

evidence for 2-photon process

S1S tunnel junction

Single mode

$H = \hbar v (a^d + a/2) - \frac{\hbar^2}{2m} (ae + e^a)$

$\Gamma_{\nu} = \frac{\rho^2}{\hbar \nu}$

$\langle \Delta P \Delta \phi \rangle = \frac{1}{2\hbar \nu \nu_0}$

second-order coherence function

$g^{(2)}[\nu] = 1 - \frac{\langle \Delta P \Delta \phi \rangle}{\langle P \phi \rangle^2}$

Hofheinz et al., PRL 108, 217005 (2012)

First DC test: Hofheinz et al., PRL, 73, 3405 (1994)