Universität Konstanz

SFB 767 Kolloquium

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Josephson photonics: Quantum microwaves with Josephson junctions in the inelastic Cooper pair tunneling regime

In superconducting quantum circuits the Josephson junction is the key element because it is the only strongly nonlinear and dissipationless circuit element we know. Usually it is used in the superconducting state where it acts as a nonlinear inductor. But a small Josephson junction can be nonlinear and dissipationless also when a non-zero DC voltage below the gap is applied to it. In this case a Cooper pair current can flow through the junction when the energy 2eV of a tunneling Cooper pair can be dissipated in the linear circuit surrunding it, in the form of photons emitted into one or several of its modes[1-2]. In this inelastic Cooper-pair tunneling regime, the junction acts as a nonlinear drive on the linear circuit, with a nonlinearity that can be controlled by the caracteristic impedance of these modes. For high-impedance circuits, nonlinear terms can even dominate, mimicing a world with fine structure constant > 1.

I will show experiments demonstrating that such a nonlinear drive can be used to generate nonclassical microwave radiation, with anti-bunched photon statistics[3-4]. By replacing the Josephson junction with a DC SQUID and modulating the flux through it we have transformed this device into a very bright microwave single photon source, able to emit single photons on demand at very high rates of the order of 100 MHz [5].

In a second part I will briefly show measurements on microwave reflection off a Josephson junction in the inelastic Cooper pair tunneling regime. Microwave reflection is closely related to photon emission via fluctuation-dissipation theorem and in certain cases we observe microwave amplification.

[1] T. Holst et al., Phys. Rev. Lett. 73, 3455 (1994) [2] M. Hofheinz et al., Phys. Rev. Lett. 106, 217005 (2011)
[3] B. Kubala et al., Phys. Scr. T165, 014029 (2015) [4] J. Leppäkangas et al., Phys. Rev. Lett. 115, 027004 (2015)
[5] A. Grimm, PhD Thesis (Université Joseph Fourier, Grenoble, 2015, https://tel.archives-ouvertes.fr/tel-01274276)

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Kaffee und Tee um 15:15 Uhr, Vortrag um 15:30 Uhr in P 603

Ansprechpartner: G. Rastelli, 3802

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