Antibunched photons emitted by a dc-biased Josephson junction

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We show that a dc-biased Josephson junction in series with a high impedance microwave resonator emits antibunched photons, see figure 1. A micro-fabricated spiral coil allows reaching a 1.97 kΩ characteristic impedance for a 4.4 GHz resonance frequency. The junction bias voltage is set so that the electrostatic energy 2eV gained by the tunneling of a Cooper pair coincides with the energy of a photon in the resonator. Upon increasing the characteristic impedance of the resonator, one enters a strong coupling regime where the presence of a photon in the resonator inhibits further Cooper pair transfer, as sketched in Fig. 1. When measuring auto-correlations of the radiation leaking out of the resonator, see Figure 2, we find for the emitted photons a zero-time second order correlation function of 0.3 significantly smaller than 1, which demonstrates antibunching. Note that this antibunching occurs at a large emission rate of 6 10^7 photons per second. The strong coupling regime of a dc biased Josephson junction to its electromagnetic environment greatly enriches the coupled dynamics of quantum electrical transport and electromagnetic radiation. It could allow the investigation and exploitation of the radiation emitted by quantum conductors, such as the emission of many photons in a single tunneling process, the demonstration of parametric transitions, of the stabilization of a Fock state by dissipation engineering, or the development of new types of quantum bits circuits.

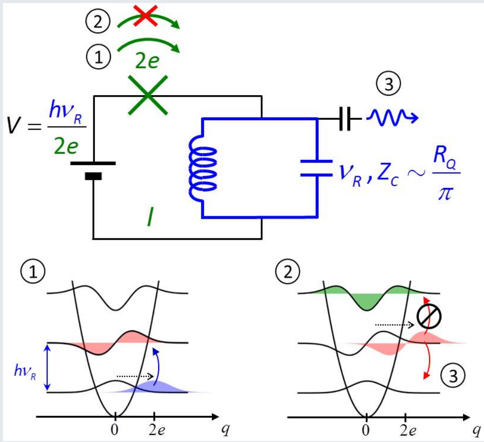

*Figure 1: **Principle of the experiment**. A Josephson junction is placed in series with a resonator with frequency ν_R and characteristic impedance Zc of the order of the quantum of resistance R_Q=h/4e². It is voltage biased so that tunneling of a Cooper pair creates a photon in the resonator initially empty (1). Due to Coulomb blockade, the tunneling of the next Cooper pair is inhibited (2) until the previous photon has leaked out of the resonator (3). The photons emitted are thus antibunched, which is revealed by measuring the $g^{(2)}$ function of the continuous microwave signal (3).*

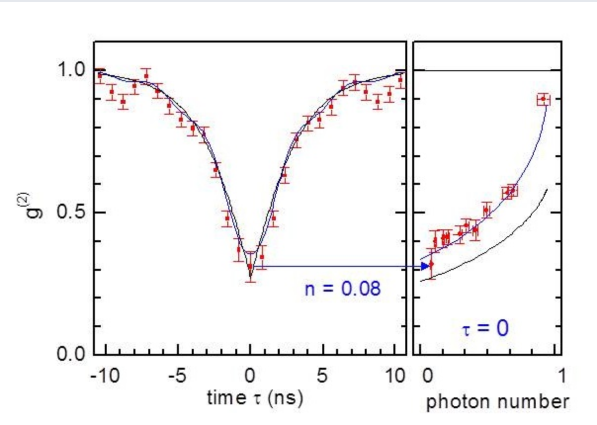

*Figure 2: **Antibunching of the emitted radiation**. Left panel: second order coherence function correlation function $g^{(2)}(\tau)$ as a function of time for n = 0:08 photons in the resonator. Dots are experimental data and the dashed line is our theoretical prediction. Right panel: g2(0) as a function of n. Dots are experimental data, the solid line is our theoretical prediction.*

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