Experimental Test of the Entanglement of Radiation Generated by the Dynamical Casimir Effect

B. Schneider[1,], M. Simoen[1], I.M. Svensson[1], A. Bengtsson[1], T. Aref, J. Bylander[1], C.M. Wilson[2], G. Johansson[1], and P. Delsing[1]

[1]Chalmers University of Technology, Sweden

[2]University of Waterloo, Canada

Email of Presenting Author: bens@chalmers.se

In the dynamical Casimir effect (DCE), a boundary condition for the electromagnetic field is changed rapidly, resulting in generation of pairs of photons [1]. This was experimentally demonstrated in 2011 [2]. Both generation of photons and two-mode squeezing were observed. Quantum theory predicts that the photon pairs are entangled and that the resulting electromagnetic field is in a nonclassical state at zero temperature. Johansson et al. [3] recently suggested how to test entanglement of the DCE radiation by evaluating the log negativity.
Here we present such an experimental test. We have measured a sample consisting of an open transmission line terminated by a superconducting quantum interference device (SQUID). The electrical length of the transmission line can be modulated, by changing the magnetic flux through the SQUID loop. Broadband radiation of photon pairs is observed along with strong two mode squeezing. The system is characterized at a temperature of <20 mK, and the signal level is calibrated using the SQUID as a shot-noise source. We investigate the cross-correlations for the field at two different frequencies and we recover the covariance matrix. From this matrix we determine the log negativity, which shows weakly positive values indicating that the two modes are entangled. A source of entangled photons can be useful in quantum information applications, for instance to entangle qubits [4].

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