Circuit QED as an experimental platform for analog quantum relativistic effects

Sorin Paraoanu, Aalto University, Finland

Superconducting quantum circuits offer an attractive platform for the simulation of effects predicted in quantum field theory but not yet confirmed experimentally.

In this talk I will focus on our experiment [1] on the dynamical Casimir effect, a process in which the ground-state (vacuum) fluctuations of a field are transformed into real particles (photons in our case) due to fast changes in the parameters of the Euler-Lagrange equations. By using an external magnetic field, we modulate the kinetic inductance per unit length of an array of SQUIDs. To measure the outgoing radiation, the array is out-coupled into a transmission line, via a low-dissipation (no-dielectric) capacitor realized with FIB (focused ion beam). This forms a cavity with quality factor Q = 50-100 and a resonant frequency tunable by magnetic field. We pump the device at 10.8 GHz and measure the spectrum and the correlations of the photons created by the dynamical Casimir effect at a frequency around 5.4 GHz.

I will also present further theoretical aspects of the modeling of this experiment, such as the role of two-photon dissipative processes and the issue of backaction. Then I will discuss the connection between this experiment and other effects that rely on the instability of the quantum vacuum, namely the Hawking radiation, the Unruh effect, and the Schwinger effect. In the end I will describe the possibilities opened by circuit QED platforms as a playground where concepts from quantum information and gravitation can be combined and tested experimentally.

[1] P. Lähteenmäki, G.S. Paraoanu, J. Hassel, and P.J. Hakonen, Dynamical Casimir effect in a Josephson metamaterial, Proc. Natl. Acad. Sci. U.S.A. **110**, 4234 (2013).