# Theory of photonic Joule effect in superconducting circuits

**Samuel Cailleaux[1], Quentin Ficheux[1], Nicolas Roch[1] and Denis Basko[2]**

[1] *Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France*
[2] *Univ. Grenoble Alpes, CNRS, LPMMC, 38000 Grenoble, France*

When a small system is coupled to a bath, the bath's state is typically assumed to be unaffected by the system, due to the large number of degrees of freedom in the bath. Here we show theoretically that this assumption can be easily violated for photonic baths typically used in experiments on superconducting circuits. We study the dynamics of a voltage-biased Josephson junction coupled to a photonic bath, represented by a long Josephson junction chain or a superconducting transmission line. We find that the system reaches a non-equilibrium steady state where the photonic degrees of freedom can be strongly overheated, leading to a qualitative change in the $I-V$ curve. This is reminiscent of the familiar Joule effect in electrical conductors where electrons can be strongly heated up by a flowing current.