The quasiparticle generation efficiency in a superconductor measured over a broad frequency band

Main author:

DE VISSER Pieter

Co-authors:

Baryshev Andrey, SRON Netherlands Institute for Space Research, Landleven 12, 9747AD Groningen, The Netherlands / Kapteyn Astronomical Institute,

Baselmans Jochem, SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands / Terahertz Sensing Group, Facul

DE VISSER Pieter, Kavli Institute of Nanoscience, Faculty of Applied Sciences, Delft University of Technology

Goldie David, Quantum Sensors Group, Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, United Kingdom

Guruswamy Tejas, Quantum Sensors Group, Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, United Kingdom

Klapwijk Teun, Kavli Institute of NanoScience, Faculty of Applied Sciences, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Ne

Llombart Nuria, Terahertz Sensing Group, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, Me

Neto Andrea, Terahertz Sensing Group, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, Me

Withington Stafford, Quantum Sensors Group, Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, United Kingdom

Yates Stephen, SRON Netherlands Institute for Space Research, Landleven 12, 9747AD Groningen, The Netherlands

We have measured the absorption of terahertz radiation in a BCS superconductor over a broad range of frequencies from 200 GHz to 1.1 THz around the gap frequency of the superconductor (324 GHz). We use a broadband antenna-lens system and a tantalum microwave resonator (MKID). Starting at low frequencies, the response of the resonator is zero, until it rapidly rises to a maximum at the gap edge of the superconductor, where photons have enough energy to break Cooper pairs. From there on the response drops to half the maximum response at twice the pairbreaking energy, because the generated quasiparticles do not have enough energy to break an additional pair. At higher frequencies, the response rises again due to trapping of pair-breaking phonons in the superconductor.

In practice this is the first measurement of the frequency dependence of the quasiparticle creation efficiency due to pair-breaking in a superconductor and is as such an important parameter for all superconducting pair-breaking detectors. It determines the responsivity of the detector for a specific excitation frequency and determines the weight of the quasiparticle recombination noise contribution of the detector, even in the photon-noise dominated regime. The quasiparticle generation efficiency, calculated from the different nonequilibrium quasiparticle distribution functions at each frequency at constant power, is in agreement with the measurements.

This research has just been published: Applied Physics Letters 106, 252602 (2015).