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Interplay between kinetic inductance, nonlinearity and quasiparticle dynamics in granular aluminum MKIDs

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Microwave kinetic inductance detectors (MKIDs) are thin film, cryogenic, superconducting resonators. Incident Cooper pair-breaking radiation increases their kinetic inductance, thereby measurably lowering their resonant frequency. For a given resonant frequency, the highest MKID responsivity is obtained by maximizing the kinetic inductance fraction α. However, in circuits with α close to unity, the low supercurrent density reduces the maximum number of readout photons before bifurcation due to self-Kerr non-linearity, therefore setting a bound for the maximum α before the noise equivalent power (NEP) starts to increase. By fabricating granular aluminum MKIDs with different resistivities, we effectively sweep their kinetic inductance from tens to several hundreds of pH per square. We find a NEP minimum in the range of 30 $\mathrm{aW}/\sqrt{\mathrm{Hz}}$ at $\alpha \approx 0.9$, which results from a trade-off between the onset of non-linearity and a non-monotonic dependence of the noise spectral density versus resistivity.

Student (Ph.D., M.Sc. or B.Sc.)

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Less than 5 years of experience since completion of Ph.D

N

Primary author: VALENTI, Francesco (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany; Institut für Prozessdatenverarbeitung und Elektronik, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany)

Co-authors: HENRIQUES, Fabio (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); CATELANI, Gianluigi (JARA Institute for Quantum Information (PGI-11), Forschungszentrum Jülich, 52425 Jülich, Germany); MALEEVA, Nataliya (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); GRÜNHAUPT, Lukas (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); VON LÜPKE, Uwe (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); SKACEL, Sebastian T. (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany ; Institute of Nanotechnology, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany); WINKEL, Patrick (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); BILMES, Alexander (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany); USTINOV, Alexey V. (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany ; Russian Quantum Center, National University of Science and Technology MISIS, 119049 Moscow, Russia); GOUPY, Johannes (Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France); CALVO, Martino (Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France); BENOÎT , Alain (Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France); LEVY-BERTRAND, Florence (Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France); MONFARDINI, Alessandro (Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France); POP, Ioan M. (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany ; Institute of Nanotechnology, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany)

Presenter: VALENTI, Francesco (Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany; Institut für Prozessdatenverarbeitung und Elektronik, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany)

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