BOLOMETRY AT EXTREME

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Microwave and terahertz nanobolometers can be used as ultrasensitive power meters in applications such as spectral mapping of extraterrestial low-energy electromagnetic radiation [1]. Bolometers are characterized by a quantity referred to as noise equivalent power (NEP), i.e., the noise spectral density in the bolometer readout with respect to the input power.

Intense development of nanobolometers has taken place for well more than a decade with the aim to reach NEP $= 10^{-20}$ W/$\sqrt{\text{Hz}}$ which is required, for example, in efficient measurements of the terahertz spectrum in space [1]. Furthermore, bolometric observation of single photons at increasingly long wavelengths is a long-standing goal with the previous energy resolution falling above 10 zJ [2]. A single-photon microwave detector would have a multitude of applications in the emerging field of quantum technology. For example, it could enable wireless quantum-enhanced cryptography protocols.

We present a microwave nanobolometer based on superconductor–normal-metal–superconductor Josephson junctions as shown in Figure 1. Using positive electrothermal feedback, we show that we can achieve a single-shot detection fidelity of 0.56 for 1.1-zJ pulses of 8.4-GHz photons [3]. This is more than an order of magnitude improvement over the previous thermal detectors. Importantly, we observe that we can reach NEP $=$ 2×10^{-20} W/$\sqrt{\text{Hz}}$ with our detector in the linear mode. This unique sensitivity finally takes bolometer NEPs to the long-awaited regime of efficient terahertz spectroscopy in space. In the future, ultrasensitive bolometers and thermometers [4] are expected to play an important role also in quantum information processing and thermodynamics.

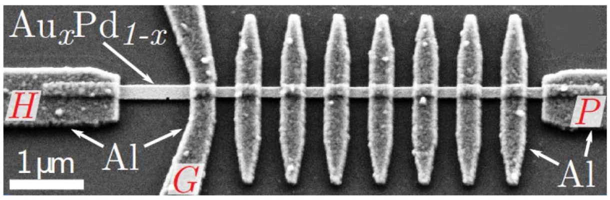

Figure 1: Scanning-electron micrograph of our nanobolometer showing a normal-metal AuPd nanowire contacted to superconducting Al islands and leads.

[1] B. S. Karasik, A. V. Sergeev, and D. E. Prober, IEEE Trans. Terahertz Sci. Technol. 1 (2011) 97.

[2] B. S. Karasik et al., Appl. Phys. Lett. 101 (2012) 052601.

[3] J. Govenius, R. E. Lake, K. Y. Tan, and M. Möttönen, Phys. Rev. Lett. 117 (2016) 030802.

[4] S. Gasparinetti et al., Phys. Rev. Appl. 3 (2015) 014007.