RECENT PROGRESS ON PHOTON-COUNTING SUPERCONDUCTING DETECTORS FOR SUBMILLIMETER ASTRONOMY

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We are developing superconducting direct detectors (the Single Quasiparticle Photon Counter, or SQPC[1]) for submillimeter astronomy that can in principle detect individual photons. These devices operate by measuring the quasiparticles generated when single Cooper-pairs are broken by absorption of a submillimeter photon. This photoconductive type of device could yield high quantum efficiency, large responsivity, microsecond response times, and sensitivities in the range of 10^{-20} Watts per root Hertz. The use of antenna coupling to a small absorber also suggests the potential for novel instrument designs and scalability to imaging or spectroscopic arrays. We will describe the device concept, recent results on fabrication and electrical characterization of these detectors, issues related to saturation and optimization of the device parameters, and work on developing integrated cryogenic readouts utilizing single-electron transistors. Since the detector is essentially a photoconductor, the ultimate limitation on the sensitivity should be the dark current of the SIS detector junction. Measurements of the dark current in several devices, with and without quasiparticle confinement, show dark currents that follow the exponential scaling with temperature expected for BCS superconductors down to temperatures of 250-300 mK. Measured dark currents at 250 mK can be picoamps or smaller, corresponding to expected NEPs less than 8 x 10^{-20} W/rt(Hz). Measurements of the actual photoresponse are in progress. As with any high-sensitivity detector, dynamic range and saturation are also important issues. In the SQPC detector, the saturation is predicted to depend on the competition between collection of the photoinduced quasiparticles by tunneling and non-thermal recombination. Based on experience with this physics in optical and UV superconducting devices, we expect a dynamic range of ~ 10^5, and a gradual saturation which could extend the useful range of background powers in operation. Finally, we have developed practical readout amplifiers for these high-impedance cryogenic detectors based on the Radio-Frequency Single-Electron Transistor (RF-SET). We will describe results of a demonstration of a transimpedance amplifier[2] based on closed-loop operation of an RF-SET, and a demonstration of a wavelength-division multiplexing scheme[3] for the RF-SET. These developments will be a key ingredient in scaling to large arrays of high-sensitivity detectors.

[1] R.J. Schoelkopf et al., "A Concept for a Submillimeter-wave Single-photon Counter," IEEE Trans. on Appl. Superconductivity, **9**, 2935 (1999).
[2] K. Segall and R.J. Schoelkopf, in preparation.
[3] T.R. Stevenson et al., Appl. Phys. Lett., in press (2002).