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SQUID-amplified photon detection: from cosmology to material science

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Superconducting photon detectors amplified by SQUIDs are playing an increasingly important role in science ranging from cosmology to materials characterization. The most widely used superconducting photon detector uses a superconducting transition-edge sensor (TES), which is a superconducting film biased in the narrow transition region between the normal and superconducting state. The film is voltage biased, and the current flowing through it is measured with a SQUID. An incident photon increases the resistance of the TES, which reduces the current through the SQUID. Large arrays of SQUID-coupled TES detectors are read out by cryogenic multiplexing of the SQUIDs with a time-division, frequency-division, or code-division multiplexing scheme. SQUID-coupled TES detectors are now widely deployed in ground- and balloon-borne observatories to measure the cosmic microwave background (CMB) radiation. By measuring the power and the polarization of the CMB, new constraints have been placed on cosmological parameters, as well as the absolute masses and number of neutrino species. Experiments are now being conducted to search for the signature of gravitational waves in the polarization of the cosmic microwave background, which would provide strong evidence of inflation at GUT energy scales. Remarkably, very similar sensor arrays to those developed for CMB measurements can also be used for spectroscopic measurements at synchrotron and free-electron laser x-ray light sources. SQUID-coupled TES sensors provide spectroscopic resolution previously only achieved with dispersive detectors based on gratings and crystal diffraction, but with the high efficiency of semiconductor x-ray detectors. I will describe experiments using SQUID-coupled TES arrays for x-ray emission and x-ray absorption spectroscopy of materials, and plans to develop much larger arrays for next-generation light sources.