Exploring the Universe with Superconducting Detectors

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It has often been said that we are living in a golden age of astronomical discovery. Indeed, over the past several decades we have pushed our knowledge of stars and galaxies to ever larger distances and earlier times using observations that span the electromagnetic spectrum; determined the age and geometry of the universe with high precision; confronted the twin mysteries of dark matter and dark energy; discovered a plethora of planets orbiting other stars, including some terrestrial planets that are potentially habitable; and very recently, directly observed the merger of two black holes for the first time through their gravitational-wave signature.

Continuing these advances will require ever more sensitive instruments. Increasing the sensitivity may translate to gathering and measuring more photons, or it may translate to extracting more information from each detected photon. For both cases, superconducting detectors offer solutions. I will discuss the history of superconducting detectors, give examples of several types of detectors and describe how they are presently being used, and illustrate the future potential as well as the challenges for this technology. Ultimately, superconducting detectors may help us to chart the far-infrared universe, characterize the atmospheres of terrestrial exoplanets, and provide direct evidence of gravitational waves produced by an inflationary epoch when the universe was around 10^{-30} seconds old.

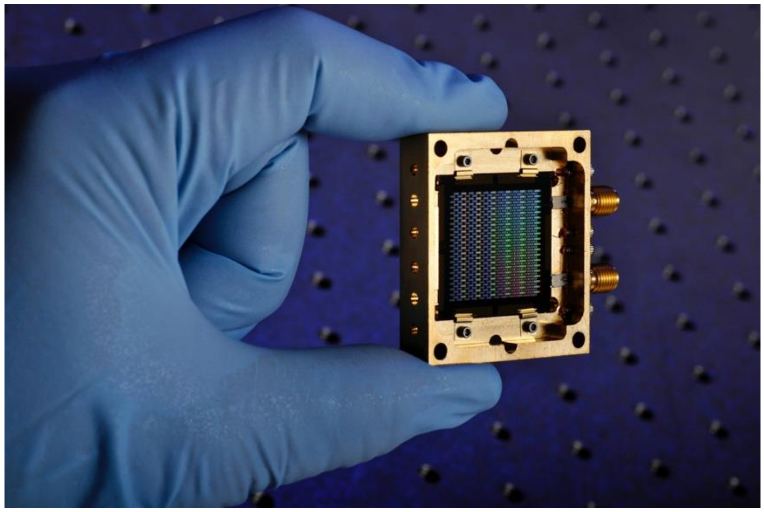

Figure 1: A far-infrared superconducting imager: This 500-pixel array of superconducting detectors is designed to produce astronomical images at a wavelength of λ=350 μm. Each pixel is an inductor-capacitor (LC) combination that resonates at a radio frequency (RF) around 200 MHz. The inductor doubles as a far-infrared absorber; the absorbed power causes the inductance to change, and the resulting shift in resonance frequency is measured using an RF probe signal. Frequency multiplexing allows the entire array to be read out using the pair of RF coaxial connectors visible on the right. The array operates at 250 mK and is produced by patterning a superconducting titanium nitride thin film using deep-UV stepper lithography.