table in the design is that residual phase-wander between the locked radio frequency (RF) and local oscillator (LO) K-band source synthesizers is canceled at an intermediate 450 MHz IF stage before final conversion to baseband through an IQ mixer.

To implement the FMCW chirp, a 2–4 GHz low-phase-noise commercial YIG synthesizer is used with a tuning bandwidth of 5 kHz, typically ramping over 350 MHz (subsequently multiplied by 36 to 12.6 GHz) in 50 ms. The chirp signal is up-converted onto the CW synthesizers' signals before multiplication. Deramping of the FMCW waveform occurs at the 600 GHz receiver mixer. While high multiplication factors should be generally avoided in FMCW radar systems to minimize the impact of phase noise in the transmitted signal, in this case, the short standoff ranges produce a phase noise floor that lies below the thermal noise except for the brightest, mirrorlike specular targets.

The submillimeter power is transmitted first through a silicon wafer beam splitter and then a plano-convex Teflon lens with a diameter of 20 cm. This lens focuses the THz beam to a spot size of ≈2 cm at a standoff range of 4 m. To achieve scanned images, a flat mirror on a two-axis rotational stage deflects the beam in the desired direction

This innovation is an improvement over an earlier submillimeter high-resolution radar. First, a faster frequency-sweeping method consisting of a wideband YIG oscillator has been implemented. Second, the data acquisition and signal processing software has been updated in order to deal with the faster radar pulse repetition rate.

The improvements mean that the 580-GHz imaging radar can now acquire three-dimensional images of people in about five minutes. It is also feasible to detect objects concealed by clothing. This capability is possible because of the improved speed and functionality of the imaging radar's hardware and software.

This work was done by Robert Dengler, Ken Cooper, Goutam Chattopadhyay, Peter Siegel, Erich Schlecht, Imran Mehdi, Anders Skalare, and John Gill of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-45156, volume and number of this NASA Tech Briefs *issue, and the page number.*

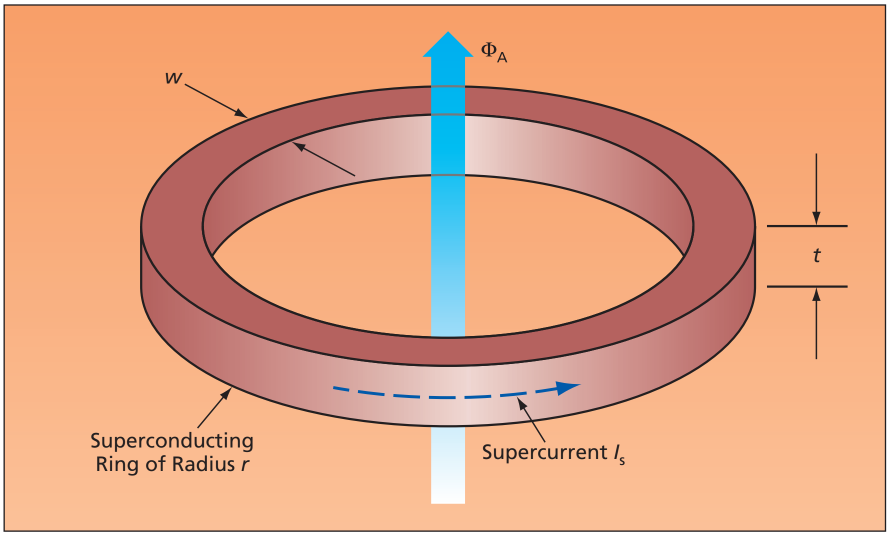
Bolometric Device Based on Fluxoid Quantization

This device offers extremely high sensitivity for radiometric applications.

NASA's Jet Propulsion Laboratory, Pasadena, California

The temperature dependence of fluxoid quantization in a superconducting loop. The sensitivity of the device is expected to surpass that of other superconducting-based bolometric devices, such as superconducting transition-edge sensors and superconducting nanowire devices. Just as important, the proposed device has advantages in sample fabrication. Two challenges of transition edge sensor fabrication are the reproducibility of the superconducting transition temperature, T_c , and the sharpness of the transition. In the proposed device, unlike in other devices, the sample would remain in the superconducting state at all times during operation. That is to say it would be maintained at an absolute temperature, T, below its superconducting T_c. Thus, the sharpness of the transition does not directly come into play. Also, the device can operate over a relatively wide temperature span of about 0.70 T_c to 0.95 T_c. Therefore, reproducibility of T_c is not important from sample to sample. These two advantages eliminate major challenges in device fabrication.

The proposal is based on the theory of fluxoid quantization in a superconducting loop (see figure) with a track width (w) less than the temperature-dependent characteristic depth of supercurrent penetration (λ) of the material. The theory has been shown to lead to the following equation:



A **Superconducting Ring** would support a temperature-dependent supercurrent I_s in the presence of an applied magnetic flux Φ_A.

$$I_s(T) = \frac{wt(n\Phi_0 - \Phi_A)}{2\pi r\mu_0\lambda_0^2}[1-(T/T_c)^4]$$

where I_s is the temperature-dependent supercurrent, t is the thickness of the superconducting ring, Φ_0 is the magnetic-flux quantum, n is an integer denoting the number of fluxoid quanta, Φ_A is the magnetic flux applied to the ring, r is the radius of the ring, and λ_0 is the characteristic depth of penetration of supercurrent at absolute zero temperature.

The applied magnetic flux (Φ_A) would serve as a bias that could be adjusted to select the mode of operation.

This flux could be generated by any convenient means — such as those used to flux bias DC-SQUIDS. To obtain one of two distinct modes of operation, one would adjust Φ_A to obtain $n\Phi_0 - \Phi_A \approx \Phi_0/2$, placing the device in the middle of the n-fluxoid quanta branch. This mode would be a radiometric one, in which the device would function similarly to a superconducting-transition-edge sensor (TES) bolometer. Assuming the proposed device would be mounted on a low-thermal-conductance membrane similar to that used for TES bolometers, it has been estimated that the responsivity would be an order of magnitude greater than that of a typical TES bolometer.

To obtain the other distinct mode of operation, one would adjust Φ_A to place the device extremely close to the transition between the n- and $(n - 1)$-fluxoid-quanta branches. In this mode, the device would function as a threshold-type sensor having potential utility in applications that involve photon counting and other counting-type detections.

This work was done by Joseph A. Bonetti, Matthew E. Kenyon, Henry G. Leduc, and Peter K. Day of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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