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The Superconducting QUantum Interference Device: Principles and Applications

The SQUID (Superconducting QUantum Interference Device) –a superconducting loop containing two Josephson junctions –is an ultrasensitive detector of magnetic flux. The principles, fabrication, and operation of the SQUID are outlined. With the aid of a superconducting flux transformer, the SQUID achieves a magnetic field noise of
10-15 T Hz-1/2; it can also be configured as a voltmeter with a noise of 10-15 V Hz-1/2. Applications of SQUIDs –ranging from geophysics to medicine and from nondestructive evaluation to quantum computing –are briefly reviewed. Two other applications are discussed in more detail. The first is a SQUID as a near-quantum-limited amplifier in the 1-GHz frequency range. This device is to be installed in the axion detector at Lawrence Livermore National Laboratory in 2006, and is expected to increase the frequency scan rate by three orders of magnitude. In the second example, a SQUID is used to acquire magnetic resonance images at 5.6 kHz, four orders of magnitude lower than in conventional MRI systems. Images of phantoms and of the human forearm are presented, enhanced contrast due to weighting by the longitudinal relaxation time is illustrated, and the ability to obtain undistorted images in the presence of metals is demonstrated. Potential clinical applications are discussed.

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