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SQUIDs: Then and Now

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In 1964, Jaklevic, Lambe, Silver and Mercereau demonstrated quantum interference in a superconducting ring containing two Josephson tunnel junctions. This observation marked the birth of the SQUID—Superconducting QUantum Interference Device. The following year saw the appearance of the SLUG (Superconducting Low-inductance Undulatory Galvanometer)—a blob of solder frozen around a length of niobium wire—that was used as a voltmeter with femtovolt resolution. Although extremely primitive by today's standards, the SLUG was used successfully in a number of ultrasensitive experiments. Today, the square washer dc SQUID, fabricated on a wafer-scale from thin films with an integrated input coil, finds a wide range of applications. One example is the use of a SQUID amplifier to read out ADMX—Axion Dark Matter eXperiment—at the University of Washington, Seattle. This experiment, which involves a cooled microwave cavity surrounded by a superconducting magnet, searches for the axion, a candidate for cold dark matter. In the presence of a magnetic field the axion is predicted to decay into a photon, which is detected by the SQUID. In another example, the combination of a SQUID with prepolarized proton spins enables one to perform magnetic resonance imaging (MRI) in magnetic fields of the order of 0.1 mT, four orders of magnitude lower than in conventional MRI systems. In vivo images of the human brain acquired at these ultralow fields are able distinguish brain tissue, blood, cerebrospinal fluid and scalp fat using a combination of inversion recovery and multiple echo sequences. Potential clinical applications are briefly discussed.