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ATTEMPTS TO DETECT GRAVITATIONAL WAVES WITH RESONANT BARS

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The radiative solution of Einstein's theory of General Relativity indicates that gravitational waves should exist, travel at the speed of light and produce ripples in the curvature of space-time. These waves are predicted to be a "dimensionless strain of space" which, for a wave travelling in direction '3', consist of two orthogonal polarizations \( h_{11} \) and \( h_{12} \) with \( h_{11} = -h_{22} \) and \( h_{12} = |h_{21}| \). In 1960 Weber published a paper suggesting experimental techniques for measuring gravitational radiation. The "resonant bar" detector he suggested is now being used by at least ten groups throughout the world.

We have made a gravitational wave detector using a pair of PZT-8 ceramic transducers 100 mm in diameter and 20 mm thick. These transducers have a rms strain amplitude in the thickness mode of \(-2 \times 10^{-14}\) at their resonant frequencies of 110 kHz due to 'kT' of noise. The frequencies of the two transducers have been adjusted, by capacitive loading, to within \(-10\) Hz of each other. The output signals from the two transducers (A, B) are amplified by tuned preamplifiers before entering summing (A + B) and difference (A - B) amplifiers. An electronic switch samples the sum then the difference at a rate of 5Hz before the signal is amplified, demodulated and sent to a lock-in-amplifier operating at the sampling frequency. This process, which enables the detector to be switched on (A + B) and then off (A - B), improves the strain sensitivity from the initial value of \(-2 \times 10^{-14}\) to \(-3 \times 10^{-16}\).

The next improvement of sensitivity is obtained by sweeping the transducers slowly around an axis parallel to the earth's polar axis with measurements being taken every 14°. These readings are stored on magnetic tape before they are processed to determine the variation in strain amplitude with detector position, universal time and sidereal time. For an integration time of 6 months the sensitivity is better than \(3 \times 10^{-19}\).

A brief summary of the theoretical reasons for the existence of gravitational radiation will be presented together with a survey of the various detectors based on the resonant bar. Finally, after describing our piezoelectric detector and the data obtained over the last 18 months, possible improvements to the sensitivity of resonant bar detectors will be discussed.