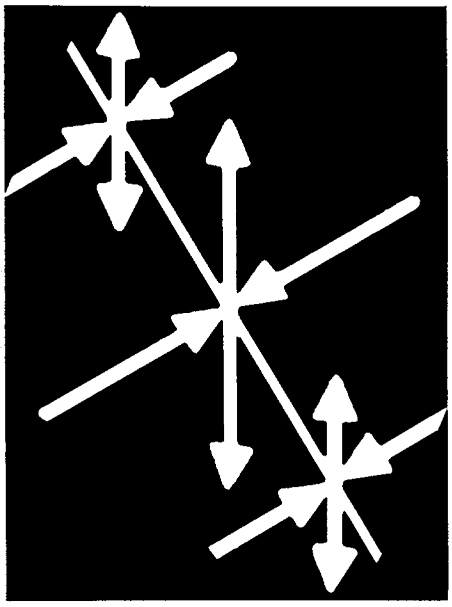
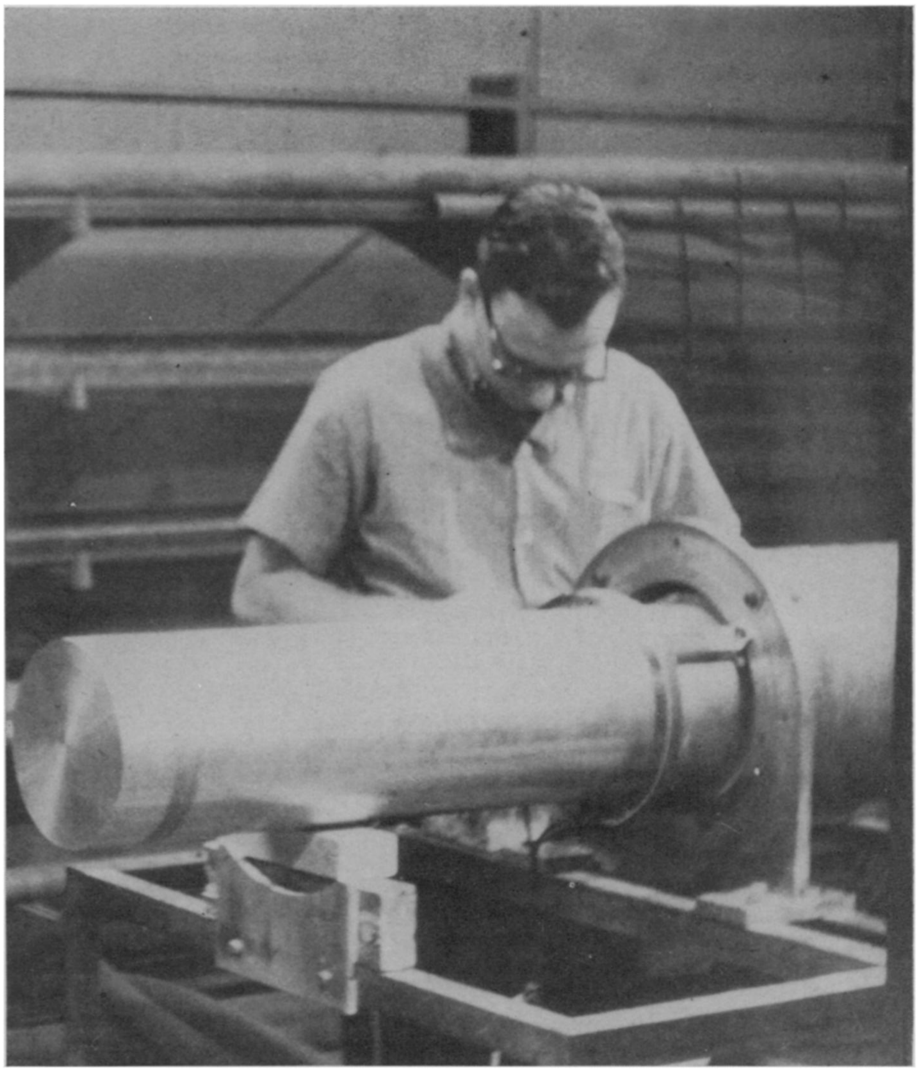


Searching for gravity waves

Two groups are looking for the hard-to-find radiation predicted by Einstein's general relativity

by Dietrick E. Thomsen



Dr. Joel Sinsky inspects one of the aluminum cylinder gravity antennas.

Almost everybody in the world listens to electromagnetic radiation, but until recently there was only one small group of physicists listening for gravitational radiation—for the excellent reason that few believe it can be found. A second group is now also at work.

Gravity wave signals, which would be useful in astrophysical and cosmological studies, may already have been received, but nobody is claiming that they have. Meanwhile, equipment developed to do the listening is finding applications in communications, seismology and prospecting.

The pioneer group in the gravity wave business is led by Prof. Joseph Weber of the University of Maryland, who has been experimenting with gravitational radiation for the last eight years. Aided by a small group of students and colleagues whose membership has changed from time to time, Prof. Weber has recorded on his equipment events that may be gravitational waves of astrophysical origin, but he is far from declaring that they are.

The second group, under Dr. Robert L. Forward, a former student of Prof. Weber's, works at the Hughes Research Laboratories in Malibu, Calif. His people have been searching with equipment that they are now convinced is not sensitive enough, and they are seeking Government support to build more sensitive antennas.

Gravity waves would be a gravitational analogue to electromagnetic waves such as radio, light and X-rays. Electromagnetic waves are nowadays taken very much for granted, although their existence—and in the case of light, their nature—was not suspected until about 100 years ago.

James Clerk Maxwell, the British mathematical physicist, had set out to find a set of mathematical equations that would predict the behavior of electromagnetic fields and from which all electromagnetic effects could be calculated. When he succeeded, he found he had gotten a bonus—the equations not only predicted the behavior of static and dynamic fields, they also postulated an electromagnetic wave that propagated with the speed of light.

In 1916 Albert Einstein published his general relativity theory, which did for gravity some of the things Maxwell's theory had done for electromagnetism. In particular it predicted that accelerated massive bodies should generate gravitational waves that would propagate with the speed of light and carry energy away with them.

This prediction, however, did not necessarily guarantee the existence of the waves. Gravity is a special case among physical effects because gravitational charge is the same as the mass of a body and therefore the laws of mechanics interfere in a way that they do not in electromagnetism.

Mechanical laws, in fact, wipe out one predicted kind of gravitational radiation, the dipole radiation of the sort so useful in radio.

But a more complicated mathematical wave form, quadrupole radiation, is still possible. Quadrupole gravitational radiation can come from rotating bodies like the earth-moon system, the shapes of which lack spherical symmetry.

This leaves plenty of room for inter-

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esting astrophysical sources, which could be a spinning oblate planet, a planet going around in orbit or, stronger still, a double star.

Collapsing binary stars are currently of substantial astrophysical interest; gravitational frequencies from these should change, in a kind of chirping effect, as they collapse. The Hughes group is especially interested in building a wideband antenna to detect the chirp and follow it over the series of frequencies collapse should produce.

Unlike electromagnetic radiation, gravitational radiation induces no net motion of the bodies it encounters. Rather it sets up tensions and compressions within them. These should be observable as tidelike fluctuations of the surfaces of extended bodies or similarly, as relative motion of two masses connected by a compressible link.

The most extended body available for such an observation is the earth itself. If the earth undergoes a periodic oscillation caused by a gravitational wave of astrophysical origin, this should be observable on the surface as a fluctuation in the local value of the earth's gravitation as the surface goes up and down. Because the radiation is really very weak, the changes that have to be measured amount to only a few parts in 100 billion, but Dr. Weber's group has developed a gravimeter sensitive enough to do the job. "The instrumentation," says Dr. Weber, "is sufficient to see changes of a few parts in 10^{11} (100 billion)."

So far the gravimeter has found nothing that looks like gravitational waves. Nevertheless, it has other uses. The National Aeronautics and Space Administration which financed its development, likes the instrument so much that it wants to send one to the moon to measure the moon's gravity.

Masses smaller than earth can be used to look for fairly high-frequency gravitational waves. The Maryland group uses aluminum cylinders weighing 1,400 kilograms to seek gravitational radiation at 1,660 cycles per second, compared to the earth's postulated longest mode of one cycle each 54 minutes.

The technology involved in developing these is formidable. Equipment that could measure and record cylinder-face displacements that amounted to a few hundredths of a nuclear diameter had to be developed; piezoelectric crystals are used. The cylinders had to be mounted in delicate isolation to prevent mechanical or electromagnetic effects from setting them into vibration.

At the Maryland campus two cylinders have been set up about a mile apart to insure against local effects. Tiltmeters and seismometers are nearby. When the cylinders respond simultaneously and the tiltmeters and seismometers are not excited, this is called an event. They occur about once a month but nobody is yet willing to give them a more specific name. The scientists would like to separate such detectors by 1,000 miles or more, to increase the certainty of the readings.

Dr. Jerome Larson (left) and Prof. Joseph Weber adjust a gravimeter.

Before the mile-apart cylinders were set up in Maryland, Dr. Joel Sinsky performed an experiment to test their sensitivity. He wanted to see whether vibrations in one of them would induce vibrations in the other by gravitational interaction. He found that this did indeed happen at center-to-center distances just under two yards.

What was involved was not gravitational radiation, but rather the dynamic field, akin to the electromagnetic dynamic field in which bodies respond to changing forces. The dynamic field dominates interactions near the source. To detect the radiation from one cylinder, Dr. Sinsky would have had to have his detector a long way from the source; the dynamic field fades away rapidly with distance and leaves the radiation dominant. And to generate radiation strong enough to be measured by his receiving cylinder, he would have needed a generating mass too large to be feasible.

What Dr. Sinsky achieved is rather the gravitational analogue of an electromagnetic transformer, which induces currents in unconnected elements by means of dynamic fields.

The group at Hughes has been working with even smaller masses in various configurations: spinning crosses or vibrating dumbbells for instance. The aim is to develop the necessary circuitry and to see what shapes and arrangements of detectors look promising. Hughes has also produced the dynamic field coupling that encouraged Dr. Sinsky.

Equipment of the sort the Hughes people are working on can be mounted in airplanes and satellites to map the gravitational fields of earth or the moon and may prove a significant ultrasensitive aid to geological studies and mineral prospecting.

Ultimately the day may come when gravitational waves are generated at will on earth and studied in the laboratory. They cannot be bent or focused since there is no material that will refract them. Nor can they be led along conductors like electrical waves. But their interference properties could be studied, and this, Dr. Forward thinks, would create new possibilities for research, possibilities that cannot yet be foreseen.