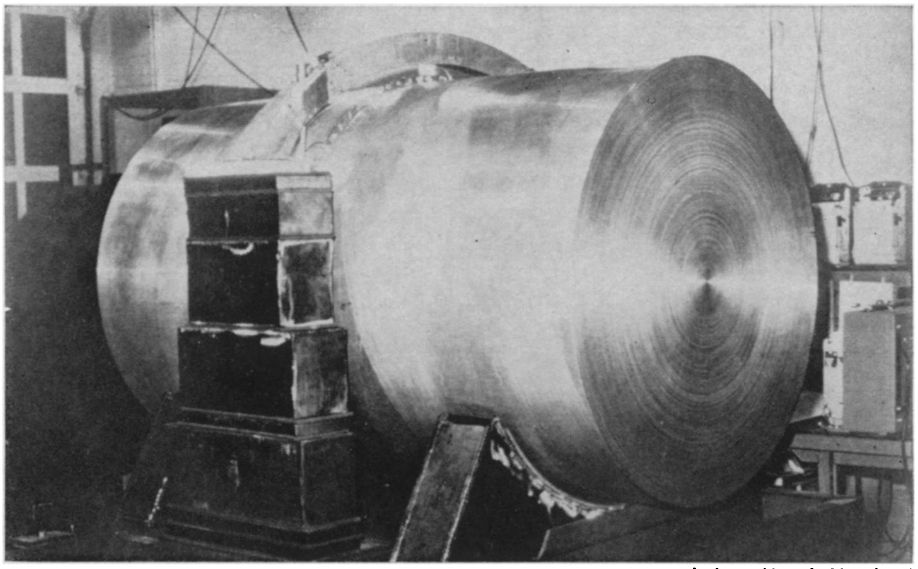
"... NO REASONABLE DOUBT"

Gravitational waves detected

A 10-year effort has found radiation many thought was too weak ever to be seen



photos: U. of Maryland

Ton of aluminum proves a theory at the University of Maryland physics lab.

Einstein's theory of gravitation, called general relativity, predicts the existence of gravitational waves. These would be energy-carrying waves involving gravitational forces analogous to the energy-carrying electromagnetic waves well-known as light and radio.

Most physicists have been willing to concede the existence of gravitational waves, but they have considered the prospect of detecting them utterly remote because the waves were believed to be extremely weak.

But one physicist, Dr. Joseph Weber of the University of Maryland, believed that he could find them. An experimental program that has lasted nearly 10 years (SN: 5/27/68, p. 408) has now brought him to say: "I think there is no reasonable doubt that we see signals. I can't escape the conclusion that some of these . . . are gravitational waves."

The discovery does for gravitational theory what Heinrich Hertz's demonstration of the reality of electromagnetic waves did for electromagnetic theory in the 1890's. It confirms a crucial prediction of the theory and opens a new field of experimental physics.

Years of studying the theory had led Dr. Weber to the belief that, contrary to the opinion of many of his colleagues, certain classes of celestial bodies should radiate gravitational waves in sufficient strength to be detected by a reasonably sized apparatus. The basic apparatus that he and a small group of associates and students have been using is an aluminum cylinder weighing about a ton. Gravitational waves, he theorized, should cause minute fluctuations in the surface of the cylinder. The fluctuations are sensed by a piezoelectric crystal, and the signal put out by the crystal is processed by a sensitive and delicate electronic circuit that ultimately yields a needle trace on moving graph paper.

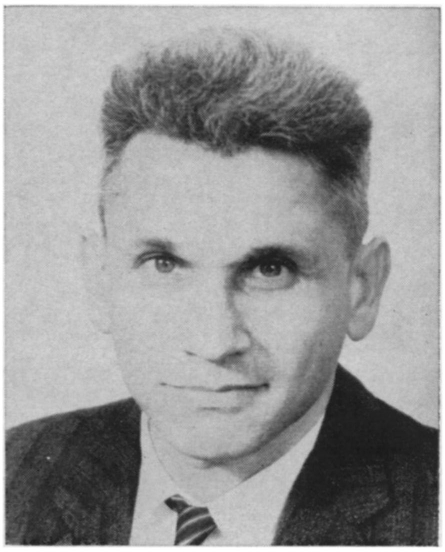
The needle traces a background of random noise vibrations of the cylinder. A sharp rise of the signal above the background constitutes an event that may be significant.

The idea of the experiment was to set up several detectors in different places and see if they would all record events simultaneously. An event on a single detector could be from some spurious cause, but coincidental readings on several detectors would help rule out the possibility of nongravitational causes.

After two detectors set up on the Maryland campus had experienced a number of coincident events, another was set up on the grounds of Argonne National Laboratory in Argonne, Ill., more than 600 miles away. Long distance coincidences began to be seen, and the statistics began to look very good: Of four coincidences recorded in a 90-day period, the chances against accident were one in 7 years, 10 years, 190 days and 48 years respectively.

Rigorous statistical analysis to rule out accident and careful recording and study of the environments of the detectors were necessary to exclude causes such as seismic or electromagnetic activity. Dr. Weber has proceeded with great caution, but gradually his statements have been getting more and more positive.

In introducing Dr. Weber to a Midwest General Relativity Conference in Cincinnati two weeks ago, one colleague said: "Whenever relativists gather, the question is: Has Joe Weber seen anything yet?" Dr. Weber's announcement that he had was greeted with applause and tributes to his achievement and perseverance from the conferees.



Weber: "Can't escape the conclusion."

The detection of waves comes at a time when there is serious question whether Einstein's theory is in fact the correct one. An alternative proposal, the so-called scalar-tensor theory, also predicts gravitational waves but in a form somewhat different from Einstein's. Both kinds of waves will excite Dr. Weber's detectors, so at present there is no way to use his work to distinguish between theories. Someday that may come too.

Though Dr. Weber's experiment does for gravitational theory what Hertz's did for electromagnetic theory, all the technological consequences that followed the successful generation of radio waves are not likely to have any analogies in the gravitational case. There are no lenses to focus gravitational waves, nor can they be led along waveguides or conductors as electromagnetic waves can.

Laboratory experiments with gravitational waves are in the range of possibility, suggests Dr. Robert L. Forward of Hughes Research Laboratories, a former student of Dr. Weber. But they would be limited to interference studies in which two trains of waves are run into each other to see how they might interact.

Astronomy is likely to be a major beneficiary of the discovery. For astronomers gravitational radiation opens a new observing dimension. Heretofore they have used electromagnetic radiation to tell them about celestial objects and have learned much about the electromagnetic, molecular, atomic and nuclear processes going on in celestial bodies. Gravitational radiation will bring information on the gravitational processes going on, and it will do so especially for those classes of objects for which gravitational processes are especially important: binary stars, collapsing supernovas and, maybe, pulsars.

Shortly after pulsars were discovered, Dr. Weber suggested they might be sources of gravitational radiation (SN: 8/17, p. 154). He now talks of designing detecting equipment for gravitational wave signals from the pulsars CP-1919 and the Crab nebula.

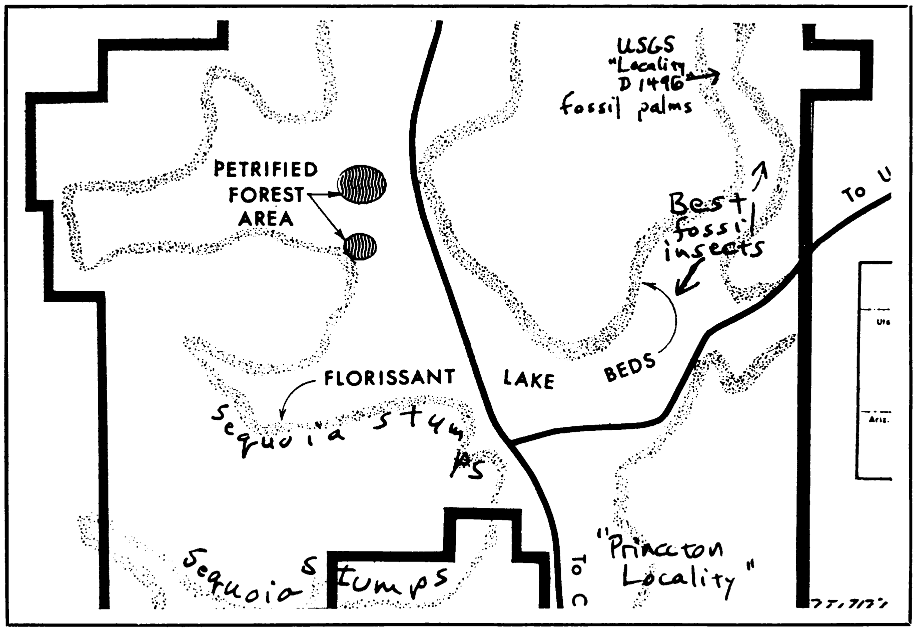
One thing that he suggests is an experiment to watch a pulsar for a year in both radio and gravitational waves. The two records could be compared in detail by a computer to see what their joint behavior could contribute to the physics of pulsars, especially fluctuations in their rates.

Dr. Forward and his group in California have been working on equipment to detect signals from collapsing binary stars, pairs of stars that are spiralling together instead of revolving at a stable distance. Such a pair would produce a chirp signal in gravitational waves, one that slides through a range of frequencies like the chirp of a bird. A wideband antenna is needed to follow such a signal through its course.

Dr. Weber's present equipment responds to only a single precise frequency. A chirp signal encountering such a detector would produce a sharp spike on the detector's signal recorder as it swept through the detector's response frequency. The signals Dr. Weber has been seeing are spikes of this sort, and he suspects they may come from some similar cataclysm. Collapsing supernovas are a possibility. ◇

FLORISSANT FOSSILS

A treasure in danger



National Park Service

Last chance: Proposed 6,000-acre Florissant National Monument in Colorado.

Fossils are the remains that enable man to decipher the story of the earth's history by unearthing messages trapped in rocks. As such they are treasured and protected by both scientists and government.

Among the fossil sites protected as national monuments in the United States are the Agate Fossil Beds in Nebraska, with remains of extinct large mammals, and the Dinosaur National Monument in northeast Utah. But the most abundant, diverse and unique fossil deposits are the unprotected Florissant fossil beds in Colorado.

Those beds are now being threatened by plans for a housing development, after almost 50 years of Government inactivity.

The Florissant area is in a mountain valley in Teller County, 35 miles west of Colorado Springs, Colo. Florissant fossils date back to the Oligocene epoch of the geologic time scale—34 million to 38 million years ago. Insects, small animals, leaves, flowers, fruits, whole plants, trees and fish fell and settled in the muddy bottom of the Florissant lake. There they were preserved, most of them intact, by tons of volcanic ash that sifted over the entire region.

Florissant's unique conditions for fossil preservation have not been found elsewhere in the world. The total picture of the entire biological community is intact, together with ample evidence of its climate.

So far, says Prof. Estella B. Leopold, of the department of biology of the University of Colorado at Boulder, at least 914 insect species and 114 species of higher plants have been found on the site.

"Florissant plant fossils are perhaps most noteworthy," says Prof. Leopold, "because they span the interval of 34 million to 38 million years, and represent a tie point in an otherwise huge gap in the plant record of the region—a gap that ranges from 26 million to 47 million years."

The conditions for fossil data-gathering at the 12,000-acre Florissant beds are excellent, Prof. Leopold says. Fossils lie within three to six inches of each other and rock layers exist often only an inch apart.

Scientists have been investigating these fossil remains for over 90 years, and since 1921 there has been a move to establish 6,000 acres of Florissant as a national monument to preserve the beds. Since the monument was proposed, it has taken 48 years for Congress to hold hearings in the field; the first was held last month. The National Park Service has been proposing acquisition formally for 17 years, and despite consideration in four previous Congressional sessions, nothing has been done.

The Senate Subcommittee on Parks and Monuments is currently considering three bills to preserve the site as a Florissant Fossil Beds National Monument. All three bills, which vary only in detail, request acquisition of 6,000 acres. This is the area found to be the most valuable after field investigations under the supervision of Prof. Harry D. MacGinitie of the University of California. But if Congress fails to act, a healthy piece of the site may be lost; 1,800 acres of the