PHYSICS

Waves Defy Detection

Gravitational waves of all large bodies are too small to be detected. Some effects of curvature do not tend to disappear as the distance from sun the mass increases, Ann Ewing reports.

➤ THE GRAVITATIONAL waves sent out by such large bodies as the sun and other stars are much too small to be detected by observations in the near future, the American Physical Society meeting was told in New York.

The waves do, nevertheless, exist, as predicted by Einstein's general theory of relativity, and travel at the speed of light, 186,000 miles a second.

Dr. Peter G. Bergmann of Syracuse University, Syracuse, N. Y., and his co-workers have explored exactly how the gravitational field of a large mass, such as the sun's, fades away at great distances. Both Einstein's gravitational theory and Newton's predict that the forces two bodies exert on each other tend to diminish as the distance between them increases, becoming arbitrarily small at very great distances.

Einstein's theory predicts that gravitation is equivalent to a curving of space and time. Dr. Bergmann and his associates found that some effects of curvature do not tend to disappear as the distance from the sun or other mass increases. All the effects are "extremely minute" for masses such as those of typical celestial bodies, Dr. Bergmann reported.

He suggested that curvature of space can best be understood by considering the geometric difference between a plane, a flat space, and the surface of a sphere, a curved space. The role of straight lines for a plane is taken over on a spherical surface by the so-called great circles, which are the most nearly straight lines that can be constructed.

When a triangle is formed out of parts of great circles, the sum of the three angles of such a "spherical triangle" is greater than 180 degrees, the value of the sum of the angles in an ordinary triangle in a plane.

Another indication of the nature of space curvature can be seen when an attempt is made to construct from great circles a "square," that is, a quadrangle all of whose four sides are of equal length and mutually perpendicular. As the "square" is built up side by side, the figure fails to close upon returning to the point of departure.

Dr. Bergmann and his co-workers examined the analogue of this last geometric test of curvature for the space surrounding a large mass, then calculated the size of the gap as a measure of the deviation of the space from flatness. They found that if the size of the figure is increased proportionally to its distance from the center, the gap does not shrink indefinitely but tends to a final value, or limit, at an infinite distance from the mass.

The magnitude of the gap is proportional to the magnitude of the mass causing the space-time curvature, and approximately equals the so-called Schwarzschild radius. The typical gap in a figure caused by a mass like that of the earth is half an inch. For a mass like that of the sun, the gap is one mile, Dr. Bergmann reported.

He said these distances are much too small to be observed with present astronomical instruments. Nevertheless, Dr. Bergmann said, "it is significant that such lower limits of accuracy exist at all."

Dr. Bergmann's co-workers were Drs. Ivor Robinson, now at Cornell University, Ithaca, N. Y., and Engelbert Schucking, astronomy professor at the University of Hamburg, Germany.

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PHYSICS

Study Physics at Home

➤ COLLEGE STUDENTS can be taught physics without ever attending a class, the American Physical Society was told in New York.

An experimental group of nine students taking the at-home course is doing about as well as 350 students taking the regular course, Dr. Jay Orear of Cornell University, Ithaca, N. Y., reported. He said students in the experimental group had, in effect, a personal tutor at home with them.

The kind of job done by a personal tutor is duplicated by a "Programmed Student's Manual for Fundamental Physics." Besides the fact that it can be worked at home, the manual has the following characteristics, Dr. Orear said:

Immediately after answering a question or working part of a problem or exercise, the correct answer is given. However, the answer is not available until after the student makes his response, and there is no way to reveal the answer or "take a peek" without first making a response.

The workbook is cheat proof in the sense that a truly indelible record is presented of all responses. Answers are revealed by drawing a line of water using a fountain pen or moistened eraser. A correct response turns green, and incorrect turns red. The colors are as indelible as printer's ink.

Each student can work at his own pace and level of difficulty. Slower-paced, easier material is automatically provided whenever a student runs into difficulty. Certain advanced material is occasionally provided only for advanced students. Each student follows his own individual path through the material, and the program automatically adjusts itself to the particular needs of each student.

A student can work long, difficult problems "on his own," without getting lost or stuck. This makes it possible for students to work problems of greater difficulty than they could handle by conventional methods.

The teaching exeperiment involved 19 students, Dr. Orear reported. They volunteered to learn the material entirely by self-study without ever attending classes. Of these, nine were randomly selected not to attend physics classes, the others to take the regular course.

Preliminary results show that the group not attending any class is doing about as well as the other group of 10. Both groups are doing as well as the 350 students taking the course, Dr. Orear reported. The 350 students use the programmed teaching manual instead of conventional homework.

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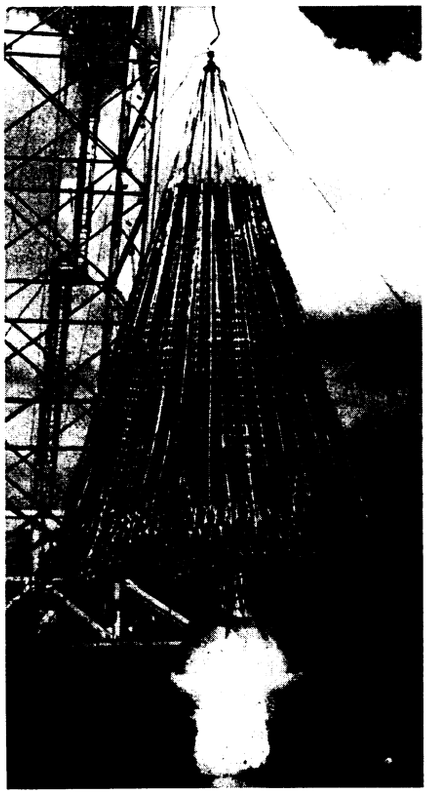

"OPERATION SNARE"—This device is used to test the advanced versions of the Navy's submarine-launched Polaris missile. It enables technicians and engineers at Lockheed Missiles and Space Company, Sunnyvale, Calif., to study the missile's underwater performance. The bag of nylon webbing is suspended with its bottom open and waiting directly above the launch tube on the ocean floor. The bag catches the missile as it breaks the surface.