Gravity Waves: Are They Real and What Do They Mean?

Because gravity waves are weak and difficult to measure, many scientists have been maintaining an attitude of respectful criticism toward the experiments of Joseph Weber, who reported a positive identification of gravitational radiation three years ago (*Science*, 27 February 1970, p. 1237.) At the Varenna International Summer School held in Italy recently, many questions about the pulses observed by Weber and his colleagues at the University of Maryland, College Park, were sharpened by the public discussion of very preliminary findings by an independent group of physicists.

Using a pair of antennas similar to those used by Weber, Vladimir Braginski and his colleagues at Moscow State University, Russia, have been looking for coincident pulses for 20 days, apparently without success. Although 20 days observation represents far too little time to establish a reliable result in the tedious search for gravity waves, Braginski's observed rate apparently provoked a rather spirited round-table discussion at the Varenna conference. Because of electronic noise which limits the sensitivity of his antennas, participants at the conference reported that Braginski does not think that his finding to date is inconsistent with Weber's energy estimates. However, different criteria for determining a coincidence, as well as various sources of noise, were among the topics which were discussed extensively. Thus, the debate over the meaning of the coincidences that Weber reports is becoming considerably more vocal as the possibility of the first independent investigation looms closer, but a resolution of the question of the identification and interpretation of gravity waves will not come overnight.

In the meantime, however, the most straightforward interpretation of the source of the gravitational radiation reported by Weber leads to a paradox. There are very few ways to observe what is happening at the center of our galaxy, where the bursts of gravitational radiation appear to originate, but a simple calculation of the amount of matter that would have to be destroyed every year to account for the total energy of the gravitational radiation observed by Weber leads to the conclusion that the entire Milky Way should already have burned out. However, a much lower estimate of the expenditure of mass has been obtained from the available astronomical data.

The smaller number could be reconciled with Weber's data if the gravitational radiation were beamed directly toward the earth rather than propagated in all directions, as Weber assumed. Different sources usually radiate gravity waves in different patterns. The pattern of radiation from a rotating binary star system, which Weber assumed to be the source of his signals, is relatively easy to calculate—indeed it is about the only textbook example available of gravitational radiation from a particular source. In a study of a different source, Charles Misner and his colleagues at the University of Maryland recently calculated the radiation produced by particles orbiting about a very massive and rapidly spinning black hole, and found that the radiation would be beamed into a very narrow cone, and would very likely be aimed at the earth. Therefore, much less mass consumption would be required. However, Misner points out that in the complete calculations the assumed particle orbits are not physically realistic. He thinks there is a chance of finding a source that is sharply beamed and physically realistic, but that no one can be sure until a number of rather difficult calculations are completed. On the other hand, Remo Ruffini, at Princeton University, Princeton, New Jersey, strongly doubts that any such sources will be physically realistic.

While theorists are performing calculations as much to improve their techniques for treating the exotic problems in general relativity as to solve the mass-loss problem, many other investigators are preparing to check the original observations.

Weber himself has begun taking data with a disk-shaped detector which is sensitive to the polarizations of gravity waves and is tuned to a different frequency [1030 hertz (hz)] from that of the original cylindrical detectors (1661 hz). The frequency range of the source is just as important for checking mass-loss estimates as the extent of directional focusing.

Also in the United States, Tony Tyson at the Bell Telephone Laboratories, Murray Hill, New Jersey, and David Douglass at the University of Rochester, Rochester, New York, are preparing antennas for operation within a year. Both detectors will be aluminum cylinders much larger than Weber's, weighing 360 kg and measuring 3½ m long, and should be at least 50 times more sensitive.

Another technique for increasing the sensitivity of a gravity-wave antenna is to cool it. At temperatures near absolute zero, the background noise due to thermal vibrations is greatly reduced. William Fairbank at Stanford University, Palo Alto, California, has been developing a large detector which will be cooled to 0.1°K and be suspended in a superconducting magnetic field. William Hamilton at Louisiana State University, Baton Rouge, and Guido Pizella at the University of Rome are planning to build similar detectors. Eventually all three detectors will be operated in coincidence, but because their development requires the perfection of several new technologies, they will probably not be ready for several years.

In the United Kingdom, three groups are preparing detectors with a sandwich-like design developed by Peter Aplin at the University of Bristol: bars like Weber's sliced in half with piezoelectric transducers placed between the halves. Ronald Drever at the University of Glasgow and Douglas Allen at the University of Reading are also preparing such antennas.

Antennas very similar to Weber's original design are being constructed by Karl Maischberger and colleagues at the European Space Research Institute in Frascati, Italy, and Hans Billing at the Max Planck Institute in Munich, Germany. They plan to eventually operate both antennas in coincidence with Weber's devices in the United States.

Considering the number of physicists preparing new experiments, it seems certain that the next few years will bring clear-cut confirmation or rebuttal of Weber's findings. Perhaps the upcoming measurements will also clarify the sort of phenomenon that appears to be happening in the heart of the Milky Way.—William D. Metz