## Trying to fit gravity waves into the galaxy

The gravitational waves that Joseph Weber of the University of Maryland has been recording for the last few years (SN: 6/21/69, p. 593; SN: 5/27/68, p. 408) are giving cosmologists and theoretical physicists serious problems. If Weber's data are correct, something serious may be wrong with our galaxy or the laws of physics or both.

Basically the problem is the intensity of the radiation that Weber records. Weber records pulses from the direction of the center of the galaxy at one frequency, 1,660 hertz. When his results are extrapolated over the 100-to-1,000-hertz range that experiment suggests the spectrum is likely to cover, the result is that the center of the galaxy appears to be converting mass to gravitational waves at a rate of about 10,000 times the mass of the sun per year.

According to the best astronomical data the total present mass of the galaxy is $10^{11}$ solar masses, and about $10^{10}$ of these are in the central area. The rate of mass dissipation suggested by Weber's results would remove all the matter in the center in something between a million and 100 million years. The galaxy is supposed to be about 10 billion years old, and the center is still there. Something has to give.

One necessary procedure is experimental checks on Weber's results. Beside Weber himself, who continues to refine his equipment, Vladimir Braginsky of Moscow State University and J. A. Tyson of Bell Telephone Laboratories in Murray Hill, N.J., now have experiments in operation.

Tyson has been particularly concerned with improving the sensitivity of the antennas used to detect the waves. Weber's original set-up has a low signal-to-noise ratio, and there is a suspicion it may miss things: The flux of gravitational radiation may be higher than has so far been determined. There is also need for measurement at various frequencies to see whether the actual spectrum of the radiation is what was inferred from Weber's results.

After completing a study of how the sensitivity of gravity-wave antennas might be optimized, which he did with G. L. Miller, Tyson put two antennas on the air to record at 4,300 hertz. One of these is at Murray Hill, the other at the University of Rochester. About six months of data have been taken and only about half of that so far analyzed. The statistics are not yet good enough to say for sure that gravitational radiation is being recorded or that the flux approximates Weber's, but Tyson has several months more data to analyze, and when that is done (in a month or two), he believes he will either be able to corroborate Weber or announce a different significant result.

Prospects seem even better for a further experiment of Tyson's. "I am most excited about a new antenna which I am constructing at Bell Labs," he says. This will be an aluminum bar 140 inches long weighing 8,000 pounds. It will operate at two frequencies on either side of Weber's and will have about 50 times the sensitivity of Weber's. It will operate in conjunction

## Luna 20 returns highland samples

Luna 20 returned to the Soviet Union last week with soil and stones drilled from the Apollonius Mountains that form an isthmus between Mare Crisium and Mare Fecunditatis. The region is located between the lunar equator and 10 degrees north on the right side of the moon's disk as viewed from earth (the eastern limb). It is about 120 kilometers north of where Luna 16 landed (SN: 9/26/70, p. 269), the only other Soviet craft to return samples from the moon. Luna 18 was probably going to land in the same area, but it crashed near Mare Fecunditatis (SN: 9/18/71, p. 188).

Moscow accounts of the Soviet triumph, were glowing. They described the materials as the "first" from the lunar continents (continents are the same as highlands or terrae). "We shall probably receive samples of genuinely continental matter and the results of this study will make it possible to judge which of the existing hypotheses is correct," said Kirill P. Florenskiy of the Academy of Sciences of the U.S.S.R.

U.S. lunar scientists agree. The theory goes something like this: The moon's high areas, such as the Apollonius site, are what is exposed of the "original" outer crust (believed to be anorthositic in composition). Most of the maria were formed later by impact and then subsequently flooded or filled with upwelling of material from below. Apollo 11 and 12 and Luna 16 returned material representative of maria. But the Apollo 11 soil samples contained hints of what was to come: The soil was found to be "contaminated" by material different in composition, lighter in color and lower in density from the mare's soil. The fragments were chemically similar to anorthosites on earth (and also similar to Surveyor 7's findings in the moon's Southern Highlands). At the time, John A. Wood of the Smithsonian Astrophysical Observatory speculated that the fragments were from the highlands. The Apollo 15 Genesis Rock was an anorthosite, reinforcing the theory.

The Luna 20 site has all the markings of a true terrae region. The Apollo 15 orbital data revealed that the area has the highest aluminum-to-silicon ratios of any area of the near side (although not quite as high as the ratios on the far side). The ratios are what one would expect from anorthositic gabbros. Thus the material could be the oldest yet returned from the moon, and U.S. scientists are eagerly awaiting a sample of it. In January, the Soviets received Apollo 14 and Apollo 15 material as part of the sample exchange agreement (SN: 5/1/71, p. 303). Last year Luna 16 material was exchanged for Apollo 11 and 12 samples. The total return of Luna 16 was three and one-half ounces, and it is expected that Luna 20 returned as much or more. To date Apollo astronauts have returned 385 pounds from the moon.

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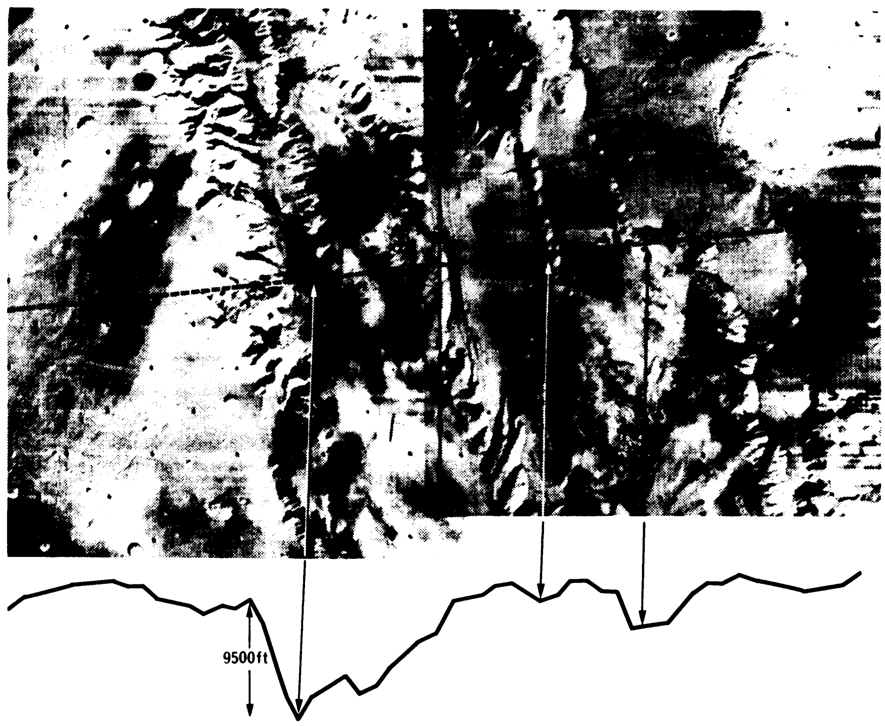
*Luna 20's snowy return with samples from the highlands.*

## A huge Martian canyon

This week Mariner 9, while on its 216th orbit of Mars, completed its primary mission objective—mapping more than 70 percent of the planet's surface. More than 6,500 photographs have been taken.

A mosaic of two of these photos reveals vast chasms and branching canyons in the Tithonius Lacus region that present a landform evolution unique to Mars—an equatorial canyon twice as deep and six times as wide as the Grand Canyon. Measurements from the ultraviolet spectrometer show the canyon, which is 75 miles across, to be 9,500 feet deep, compared with the Grand Canyon's 5,500-foot-depth and 13-mile breadth. The feature is part of a complex of canyons and ravines that extend for 2,500 miles across the Martian surface. The closest similarity on earth is the great rift valleys of Africa that run the length of the continent.




with a similar antenna being built at Rochester by David H. Douglass.

Meanwhile other experimental groups, several in the United States, in Great Britain, in Italy, possibly in Japan and Canada, are preparing equipment expected to operate in the next year or two. To prepare the minds of specialists for the results that may come and their implications, the Royal Astronomical Society of Great Britain held a one-day discussion on Jan. 14.

As might have been expected two general schools of thought emerged. Martin Rees of Cambridge University exemplified one in his statement that the validity of both Weber's results and the theory of general relativity (which governs gravity and the production of gravitational radiation) could not be accepted. Dennis Sciama of Oxford takes the other side in maintaining a hope that reconciliation may be possible.

Attempts at reconciliation tend to depend either on scrapping the assumption that the source radiates isotropically (the same in all directions) or on arriving at new formulations in general relativity that will do away with the need to destroy so much mass to get the observed radiation.

A way to get more directional radiation is to suppose that there is a rotating black hole of about 10 million or 100 million solar masses in the center of the galaxy. The black hole was first suggested by Donald Lynden-Bell and James Bardeen. Charles Misner of the University of Maryland has developed a model in which such a thing radiates linearly polarized gravitational synchrotron radiation highly concentrated in its equatorial plane. The equatorial plane of such an object would coincide more or less with the plane of the galaxy, and because the solar system also lies more or less in the plane of the galaxy, it is probable that Weber's detectors would pick up the beam.

Misner's model has been subject to some criticism in detail. Some have faulted the mechanism by which he gets the synchrotron radiation. Tyson and Douglass have done calculations that show that Weber's results do not appear to correspond to linearly polarized radiation from such a source.

The anisotropy, the concentration of the radiation into a plane, depends on the linear polarization. Tyson and Misner are engaged in a discussion of how much depolarization can be allowed so that the predicted radiation matches Weber's results and yet maintains enough anisotropy to avoid the unacceptable mass loss.

Another theoretical approach involves finding detailed solutions of the equations of general relativity for situations where the gravitational field is strong. Most of the solutions of the theory that have been done in the past have been for weak-field cases. They are somewhat easier to do, and they have been the major interest of cosmologists because large-scale gravitational fields in the universe are weak. But where gravitational waves of the observed strength are produced, fields have to be strong; since the theory is highly nonlinear, the strong-field solutions cannot be simple extrapolations of the weak-field ones.

The strong-field solutions may show that the assumed rate of conversion of mass to radiation is wrong. They may show that space-time singularities are possible. These would be circumscribed locations where the ordinary laws of physics do not apply and bizarre things can happen. Or the solutions may show that the theory needs adjustment.

Weber may be wrong. Einstein may be wrong. Something else may be wrong. Or everything may somehow be compatible. Sciama points out that it was nearly fifty years after the discovery of superconductivity that theorists managed to reconcile it with the laws of physics. Gravity-wave specialists hope this case will not take that long. □

## Abortion law upheld

The constitutionality of New York's liberal abortion law (SN: 1/29/72, p. 75) was affirmed last week by a Brooklyn Appellate Court. The suit would have halted abortions in the state's municipal hospitals and would have set a precedent for similar court actions throughout the country. The four-to-one decision was based partially on the fact that an unborn child is not a legal person. Robert M. Byrn had been appointed special guardian of all unborn fetuses by the New York State Supreme Court. He initiated the suit and now intends to appeal immediately to the State Court of Appeals. If his demands are not met there, his case, like many others, will probably eventually go to the United States Supreme Court.