tissue samples from the life forms which will be flown in the Soviet Union's own experiments.

Early in the year, NASA scientists will also offer suggestions for experiments on future Soviet probes. These could well be more elaborate than the first go-round, partly because of the available time, and are likely to include studies of gravitational and cosmic radiation effects, as well as demineralization and vestibular investigations.

The possibility of such invitational biology payloads has been an acknowledged one for a long time, but this is the first time it has been exercised by either side. □

Bad news for Brans-Dicke

In spite of the adulation that surrounds his memory, Albert Einstein did not have the last word on theories of gravitation and general relativity. There are rival formulations, not the least of which is the one of Carl H. Brans of Loyola University and Robert H. Dicke of Princeton University.

In the choice between Einstein and Brans-Dicke the shape of the sun can make a difference. It comes about this way: One of the things Einstein's theory was designed to explain was an excess precession of Mercury's orbit, an amount of precession beyond what the previous gravitational theory (Newton's) could account for. If the sun is perfectly spherical, the Brans-Dicke theory will not predict the observed amount of excess precession, and Einstein has to be preferred. If the sun is oblate, the oblateness contributes to Mercury's precession, and that plus the prediction of Brans-Dicke theory can be made to yield the observed amount.

Some observations have seemed to show some oblateness. For years now Henry A. Hill of the University of Arizona and several colleagues have been running a check with observations that attempt a precise comparison of the sun's polar radius to its equatorial radius to see if the latter is larger. Their results are in the Dec. 16 PHYSICAL REVIEW LETTERS, and they hold little seasonal cheer for partisans of Brans-Dicke.

The observation is not easy because it is not a simple thing to tell exactly where the sun's edge is. The sun sort of trails off, and the exact point to choose as the edge takes careful calculation and plausible argument. Another problem is that if the edge of the sun is brighter at the equator than at the pole, the extra brightness may give a false impression of oblateness.

It is the latter that Hill and collaborators now conclude is the case. Extra brightness at the solar equator accounts for the apparent oblateness seen by other observers. "The immediate impact of the current work removes the relevance of all earlier solar-oblateness observations to tests of gravitation theories," they write. And, in another place, "This removes the serious consequence [of previous solar-oblateness work] for Einstein's general theory of relativity."

It is cold comfort for partisans of Brans-Dicke, but it is probably not enough to make them give up yet. □

The noncosmic cosmic rays

One of Pioneer 10's earliest and most surprising discoveries about Jupiter in 1973 was that some of what scientists thought to be cosmic rays from the sun and from outside the solar system were in fact coming from the radiation belts around the giant planet. Now a group of physicists has concluded that another fraction originates nearer still, in the radiation belts of earth.

The discovery came from a satellite, Interplanetary Monitoring Platform 7, whose rotation made it possible to determine which of the charged particles it was measuring came from which direction. It also carried a particularly sensitive detecting instrument, enabling it to measure about 10 times as many low-energy protons (hydrogen nuclei below 2 million electron-volts, the "cosmic rays" in question) in a given time as had been seen before.

Thus equipped, physicists Stamatios Krimigis and John Kohl of the Johns Hopkins University Applied Physics Laboratory in Maryland and Thomas Armstrong of the University of Kansas were able to compare the proton flux from the direction of the earth with that from the direction of the sun. They discovered that even during a time in mid-January 1973, when the sun was in a particularly quiet phase, the bursts of low-energy particles pouring out from the outer (Van Allen) radiation belts trapped by earth's magnetic field kept coming at a more or less constant rate.

"Although we had long made measurements in the vicinity of the earth," says Krimigis, "we never thought that our own radiation belts were the origin of this low-energy component in the interplanetary cosmic ray spectrum. It is now clear . . . that what was previously considered part of 'cosmic rays' has its origin much closer to home. . . ."

In addition, the researchers found that the bursts seemed to correlate well with magnetic disturbances in the belts, disturbances which would create waves that accelerate the ordinarily slow-moving particles. "This gives them a kick, as it were," says Krimigis, "to where they become fast-moving nuclei and break through the belt into interplanetary space."

Low-energy cosmic rays account for less than one percent of the total low-energy spectrum, most of which is from planetary magnetospheres, so reassigning still more to the magnetospheric side leaves a minuscule amount indeed. In fact, says Krimigis, "at energies below 2 MeV, essentially most if not all [of the charged particle spectrum] is magnetospheric in origin." It is even possible, he says, that there may be no really low-energy cosmic rays reaching the solar system at all—that the polarization of the interstellar electric field turns them away, leaving nothing but magnetospheric outpourings below perhaps 20 MeV. There are no actual data available yet to prove or disprove this idea, but Pioneer 11, successor to the probe that first reassigned some cosmic rays to Jupiter (energetic electrons in that case—"cosmic rays" is a broad term), may find out as it arcs above the plane of the ecliptic on its way to distant Saturn. □

Shift toward a noncyclic universe

The controversy over whether the universe is open or closed marches on. Basically the question is this: Will the observed expansion of the universe continue forever or does the universe possess enough matter so that the mutual gravitational attraction will decelerate, stop and reverse the expansion? The first case is called open; the second closed. In an open universe, the big bang happened once and for all; in a closed universe it can repeat periodically as each collapse generates a new explosion and a reexpansion *ad infinitum*.

It is not an open-and-shut case. There are many uncertainties in the different data that must be assembled to draw a conclusion, and the argument has simmered along for decades. The latest contribution, on the open side, is by J. Richard Gott III of California Institute of Technology, James E. Gunn of Caltech and the Hale Observatories, and David N. Schramm and Beatrice M. Tinsley of the University of Texas. Unlike many previous points in the debate, this one has in the last week or so gotten into the wire services and daily newspapers and is even being discussed in pubs.

The four astronomers conclude that the total mass of the universe is a factor of 10 or 20 too small for closure. They base their opinion on a review of the currently available evidence; the most important new item appears to be the new determination of the Hubble constant by Allan Sandage of the Hale Observatories.

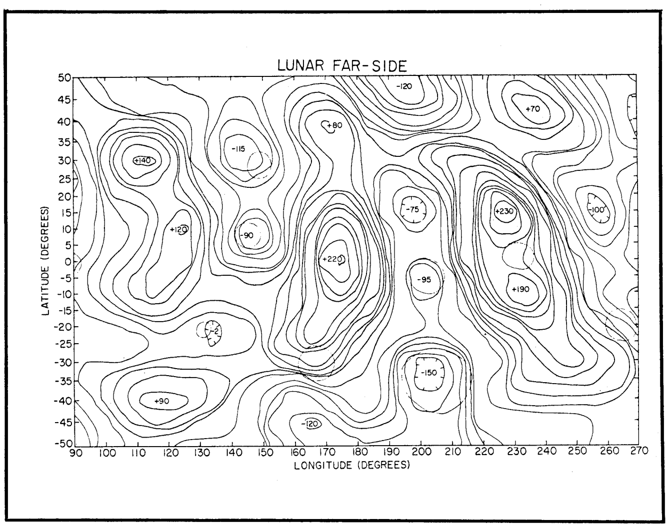
The Hubble constant measures the expansion rate. It states how much faster a galaxy appears to be rushing away from us as it becomes more distant. Sandage now makes the constant out to be 55 kilometers per second per megaparsec. From the Hubble constant astronomers can determine the so-called Hubble time, the time since the big bang if the expansion has always been at the same rate. This can be compared with a time derived from the ages of the chemical elements and theories of nuclear synthesis. If the two come out even, it means that the expansion has in fact been constant, and this is the conclusion that the California-Texas group draws. There is even a suggestion, from the work of Sandage and J. Beverly Oke of the Hale Observatories and Caltech that the expansion may be accelerating.

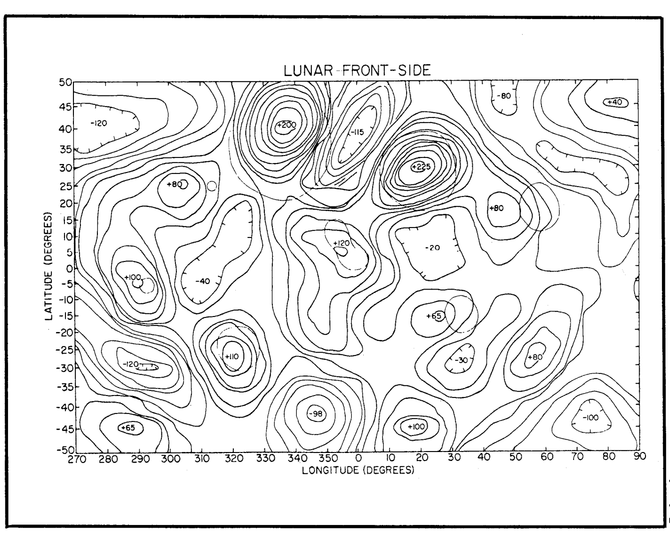
But uncertainties remain. "The evidence for the open universe is not conclusive," Gunn admits, "because each of the arguments by itself has loopholes. But we feel that openness is the most reasonable conclusion from data now at hand."

It is not likely to be the last word. The debate will surely simmer genteelly on for some time yet. □

A gravity map of the moon's far side

"Mascons," they were called—concentrations of mass below the surface of the moon, which caused strange irregularities in the lunar gravitational field. They were discovered, even before astronauts landed there, when scientists noticed unexpected changes in the orbits of moon-circling satellites. Long-term effects of the mascons sometimes built up over many orbits to as much as 100 kilometers' difference from the paths that had been predicted. The mascons were even mapped, but the charting was largely confined to the side of the moon that always faces the earth, since the satellites providing the clues were out of reach while they were behind the moon. This limited researchers to observing the changes in the orbits as the satellites came into view around the lunar disk.





Caltech

Gravity maps of the moon: The positive and negative numbers show peak gravity readings above and below normal, as calculated for 100 kilometers above the lunar surface. Contour lines denote 20-milligal intervals.

At last, after years of analysis, a California team has managed to refine these data enough to produce the first detailed gravity map of the far side of the moon, with some distinct differences from the visible face.

Alfred Ferrari and Eugene Shoemaker of California Institute of Technology and William Sjogren of Jet Propulsion Laboratory used hundreds of orbits from three different satellites, ranging in altitude from 248 miles down almost to the surface, for their calculations. Lunar Orbiter 5, which was in a near-polar orbit, provided only 10 days of data, because the researchers could only use tracking data taken after the satellite had stopped firing its attitude-control jets to set up photographic angles. A month of data from a near-equatorial orbit was taken from the tiny "sub-satellite" launched by Apollo 16 in 1972, but the major contributor was the Apollo 15 sub-satellite, which yielded 290 days of tracking from a path whose plane was tilted between the other two, at about 28.7 degrees.

The resulting map, calculated from tedious integrations and reintegrations of subtle changes in the three satellites' orbits as they passed over various parts of the lunar surface, confirmed earlier indications that the moon's "front" and "back" are not alike. Lunar Orbiter photos have shown the back side to be far more mountainous than the front, with peaks looming as much as four miles high. The new map makes their presence all the more imposing, revealing the gravity over these mountains to be as strong as that over the front-side mascons.

The map, says Ferrari, also suggests a reason that the mascons have their uncharacteristically high gravity. The major front-side mascons, he says, are all found in large basins in the lunar lowlands, where it was easy for lava flows during the moon's early years to fill them up. On the far side of the moon, however, some basins are only partly filled with lava and others not at all. The map shows gravity to be above normal over the lava-filled basins, but below normal over the unfilled ones. The logical conclusion, he suggests, is that the mascons are caused by the lava flows, rather than, as has been suggested, by the density of great meteorites lying beneath the basins they created. □