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

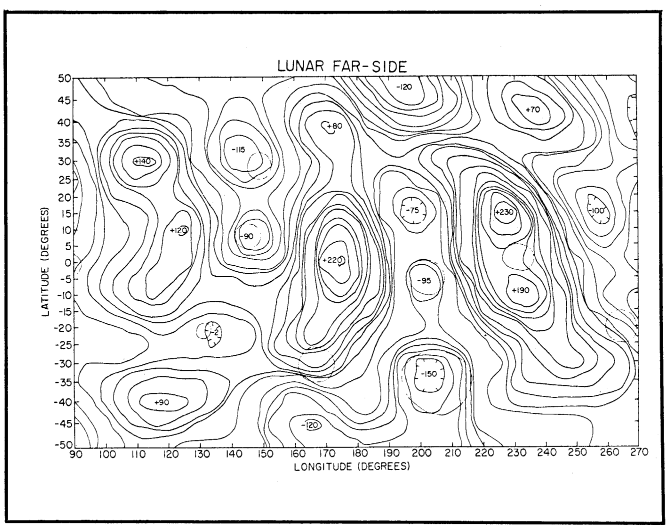
"Mascons," they were called—concentrations of mass below the surface of the moon, which caused strange irregularities in the lunar gravitational field. They were discovered, even before astronauts landed there, when scientists noticed unexpected changes in the orbits of moon-circling satellites. Long-term 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.

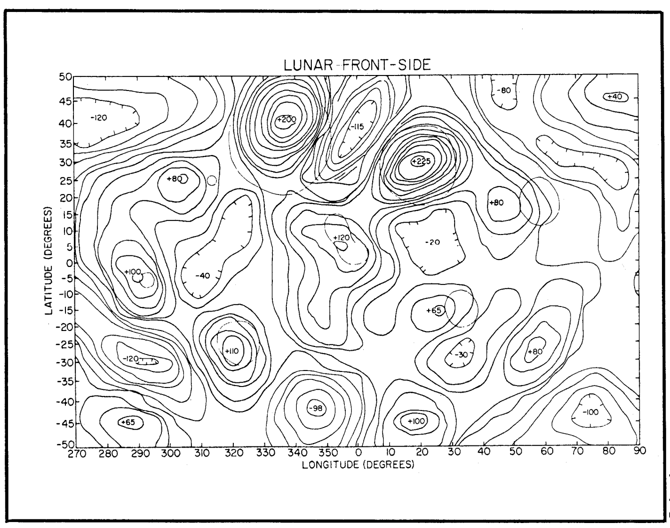
At last, after years of analysis, a California team has managed to refine these data enough to produce the first detailed gravity map of the far side of the moon, with some distinct differences from the visible face.

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. □




*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.*

Caltech