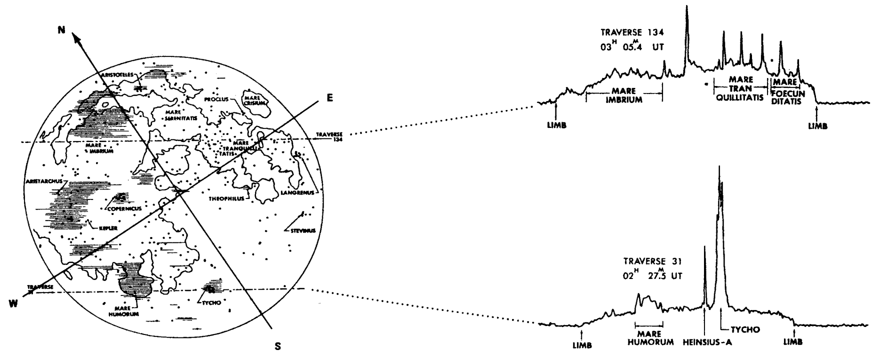
radiometer will allow Low to measure and map the surface temperature of the unilluminated portions of the moon to an accuracy of two degrees C. Many of these "hot" spots are located near bright-rayed craters, and scientists believe the hot spots are due to heat retention by ejected boulders from the craters. But some of these hot spots are not located near craters. They may be related to natural heat sources within the moon. Low should be able to differentiate debris from hard rock. He might even be able to differentiate crystalline rocks from breccias—but that's a long shot, admits NASA's Noel Hinners.



Bell Laboratories

Lunar hot spots: Surface material or internal heat? Radiometer may answer.

The ultraviolet spectrometer will measure the atomic composition of the very tenuous lunar atmosphere by observing reradiation of absorbed solar ultraviolet between 1,175 and 1,675 angstroms wavelength. William E. Fastie of Johns Hopkins University hopes to determine the height of the constituents as well as measure the far ultraviolet albedo and how it varies geographically. He will also use the instrument to look at far UV galactic emissions and study distribution of atomic hydrogen between earth and the moon.

The panoramic and metric cameras are also in the orbital package again as on Apollos 15 and 16.

All this plus about 200 pounds of rocks and soil (Apollo 16 returned 208), plus the astronauts' observations, should keep scientists busy for a while. Although this is the last Apollo, Evans said in a press conference this month that the crew feels that the flight "is just the beginning" of man's exploration of the universe. With all this data, Project Apollo will certainly have given scientists a running start. □

Next: "A geologist goes to the moon"

The 'lost' particles of physics

Where, oh where are the quarks, the heavy leptons, and the intermediate vector boson?

by Dietrick E. Thomsen

Physicists have discovered more than 100 subatomic particles. Many were unexpected, and some of the particles seem superfluous. But in the midst of finding things they don't want, physicists are having a difficult time finding some things they do want. There are a number of predicted particles whose existence is important to one theory or another that physicists so far have not been able to find. Primarily these are the quarks, the intermediate vector boson and heavy leptons.

Reports of searches for these particles were summarized at the 16th International Conference on High Energy Physics by Robert Adair of Yale, who said he was chosen because "my colleagues and myself are the only ones to have mounted massive searches for all of them. In some circles that is held to indicate a weakness of character."

The most fundamental of these unfound particles is the quark. Quarks were invented simultaneously by Murray Gell-Mann and George Zweig both of California Institute of Technology. They found that the properties of particles belonging to the classes called mesons and baryons could be explained if the particles were regarded as being made up of two or three constituents called quarks. Only three different quarks are required to build up the known mesons and baryons.

As soon as the theory was out, experimenters began to look for quarks in spite of Gell-Mann's insistence that they are not real. The theory is perfectly good if the quarks are never free but always bound together inside particles. Gell-Mann points out that a free quark would be a somewhat different particle from his constituent quark; it would obey a different statistical law. Nevertheless he agrees that experimenters should go on looking, although he says, "If they find one it won't be my quark."

Gell-Mann's or not, the search for quarks has been disappointing. The attempts don't seem to have found anything. One problem is that there is no way of guessing the mass of a quark. One thing that should help is that quarks would have only a fraction of the electric charge that other particles have, one-third or two-thirds. But if the lowest possible quark state happened to contain two quarks bound together, it could have unit charge and appear electrically like any particle.

Most physicists who have looked for quarks have supposed that the reason they couldn't find any was that quarks are too massive to be produced in the most energetic collisions available up to now. If that is so, the Intersecting Storage Rings at the CERN laboratory in Geneva ought to be able to find heavier quarks than any previous experiment. But proton-proton collisions in the rings that were equivalent to striking a stationary target with a proton of 1,250 billion electron-volts 1,250 GeV) failed to find any.

The other place to look for quarks is the cosmic rays. These observations also give a null result.

Both the intermediate vector boson and the heavy leptons are products of theoretical struggles with the weak subnuclear interaction. The weak interaction seems closely related to the electromagnetic interaction, and several theories that unite the two are now a focus of experimental attention. All these unifying theories require either heavy leptons or an intermediate vector boson or both.

The IVB would be the particle that acts as intermediary for the weak interaction, carrying its effect from one particle to another, as the photon does for electromagnetism and various mesons do for the strong interaction.

"Heavy lepton" is something of a contradiction in terms, since lepton means lightweight. The known leptons, particles particularly connected to the weak interaction, are four: the electron, the muon and the two kinds of neutrino. To these, the theory would add several longlived (10^{-11} seconds) unstable heavy particles.

The Adone storage ring at Frascati, Italy, is a good place to look for heavy leptons. Adone clashes a beam of electrons against a beam of positrons. This is a lepton-antilepton collision and it might easily produce the leptons that are being looked for. Experiments to detect leptons with masses of 700 million and 900 million electron-volts failed to turn up any. The Frascati people hope to go above one GeV fairly soon.

If you can't find heavy leptons in lepton-lepton collisions, you look at hadron-hadron interactions. Hadrons are particles associated primarily with the strong interaction: protons, neutrons, mesons and various resonances. As Adair describes it, such a collision creates a kind of subnuclear fireball. Out of this fireball comes a gamma ray which decays into a lepton-antilepton pair. Theoretically the cross section for the production of heavy lepton pairs is approximately equal to that for muon-antimuon pairs and electron-positron pairs. Armed with this information, an experimenter can do a definitive experiment, one where "no" really means "no" rather than "not yet." The technique for doing such an experiment has yet to be worked out.

Meanwhile an experiment has been done at Serpukhov in Russia, which looked for quasistable heavy leptons in the products of a proton collision with a stationary target. The Serpukhov experimenters sought particles with mass equivalent to about one GeV that would pass through a lot of matter and have a lifetime greater than 10^{-8} seconds. They found none.

The intermediate vector boson has been the object of a long search. Last year a group of experimenters working in a mine near Salt Lake City reported what they thought was evidence for the existence of the intermediate vector boson (SN: 8/21/71, p. 121). They were looking for muons that would come from the decay of the IVB and they set up their experiment in a mine deep inside a mountain to shield it as well as possible from other particles. An attempt to confirm this in a gold mine in the Kolar Goldfields in India yielded what the Indian researchers consider a strong negative. Meanwhile other groups, one a collaboration between people from the Universtiy of California, Berkeley, and the Stanford Linear Accelerator Center, the other a collaboration of people from the University of California at San Diego, Yale and Brookhaven National Laboratory, report "slight counterindications" of the Utah result.

In spite of the so-far relatively fruitless searches, experimenters continue to look for these particles because theorists would be so happy to have them. There is still a very real hope of finding them as the world's two new pieces of high-energy equipment, the CERN ISR and the U.S. National Accelerator Laboratory really get into their stride. □

NOTICE TO SCIENCE TEACHERS

The advertisement on p. 232 of the Oct. 7 SCIENCE NEWS soliciting entries in the Westinghouse Science Talent Search inadvertently gave a wrong deadline for entries. The correct deadline date is Midnight, Dec. 15, 1972. The contest is open to those students expected to complete college entrance qualifications before Oct. 1, 1973.

Further details and entry materials can be obtained from:

Science Service
1719 N St. N.W.
Washington, D.C. 20036