Ripples in Physics: Apparent Failure of Muon Conservation

Conservation laws are one of the chief weapons that physicists use in attempting to impose some intellectual order on the fast-changing world of subatomic particles. Conservation laws impose limits on the sorts of particle transmutations that may take place by decreeing that, whatever happens, certain properties possessed by the particles must be conserved. Conservation of electric charge is an example: If a positively charged particle decays, among the decay products there must be a net electric charge of one positive unit.

Conservation laws are usually empirically determined: In millions of different particle activities, experimenters note that a certain quality is conserved, so they propose an appropriate conservation law. It becomes one of the tasks of theory to explain the existence of the conservation laws either prospectively, by prediction, or retrospectively, by "retrodiction," as Steven Weinberg of Harvard University put it in a talk at the meeting of the American Physical Society in Chicago last week. Conservation laws occasionally break, and when they do, theorists must readjust or repredict. In his talk, Weinberg made public a rumor that had been going around the meeting about such a violation, mentioning an experiment that seems to violate the law of muon conservation. The rumor has been causing quite a ferment among theorists.

Muons are among the very small class of particles called leptons. There are only four leptons whose existence has been thoroughly confirmed: the muon, the muon neutrino, the electron and the electron neutrino. (There is strong evidence for the existence of more leptons, but it is indirect and not yet entirely satisfying.) Small as is the group of known leptons, it appears to be divided into a muon "family" and an electron "family" by separate conservation laws. It has appeared that there were separate qualities of muonness or "muon number" and electronness or "electron number" that were separately conserved. Electron number belongs to the electron and the electron neutrino, muon number to the muon and the muon neutrino. What the conservation law for muon number means in practice is that when a muon decays, there must be a muon neutrino among the decay products. The observation cited by Weinberg amounts to a very few examples of muon decay that does not include the muon neutrino among its products.

The experiment took place at the Swiss Institute for Nuclear Research near Zurich, and it seems to have shown six examples of a process in which the muon decays into an electron and a gamma ray, rather than the more common result of electron, muon neutrino and electron antineutrino. In response to a query from SCIENCE NEWS, J. P. Blaser of SIN replied with the following quasiconfirmation:

"In a preliminary experiment at SIN on the gamma decay of the muon (authors W. Dey, R. Engfer, W. Eichenberger, C. Petitjean, H. P. Povel, A. van der Schaaf and H. K. Walter) six events were observed which cannot easily be explained by radiative muon decay or other known backgrounds. However, there is no sufficiently significant proof at this stage that these events really originate from gamma decay of the muon. The experiment will be continued with an improved setup." Radiative decay is the kind allowed by the conservation law; gamma decay is the forbidden kind.

If this appearance should be confirmed and the rate of conservation-violating decays remains what it now appears to be, the law will be violated by one muon decay in a billion according to figures cited by Weinberg. Thus it becomes a law that holds in most cases but is "weakly violated." In theoretical terms this demotes muon conservation from an "exact symmetry of nature" to an "approximate" one. As Weinberg points out, the unified field theory of subatomic particles that he and others have been working on for years has been quite successful in explaining several previously discovered weak or partial violations of conservation laws. These are among the retrodictions he cites. ("I think that's a real word," he says.) If the experimental evidence for violation of muon conservation becomes compelling enough, theory might deal with it by postulating a new, very weak, class of force in nature, or by adjusting the number of leptons theoretically allowed to exist.

Of course, as Weinberg stresses, physicists should always keep in the back of their minds the possibility that a given conservation law may break. There never was any evidence *for* muon conservation, he reminds us; there was only no evidence *against* it. That is the status of most conservation laws. □

Viking's search for life: Another mystery

The two Viking landing craft on the surface of Mars are continuing to seek answers to the towering question of life on that surprising planet, and answers they are getting—of a sort. But what are they answering? The latest test has seemingly tilted the scales away from biology, yet at the same time it may have knocked out the supports from beneath one of the few nearly accepted parts of a nonbiological explanation for the tantalizing results of past tests.

One of Viking's three kinds of biological experiments is a "pyrolytic-release" device, which exposes a Martian soil sample to a radioactively tagged atmosphere and then incinerates it to see if the gases given off show that any of the tagged carbon compounds have been assimilated. Previous runs with the instrument have shown that premoistening the sample with water produces a lower response in the data, as does heating the soil (to well below incineration temperatures) beforehand. If Martian microorganisms are present, the inference went, their lack of response after such treatment suggests that they were either drowned or cooked. Alternatively, nonbiologic chemical reactions were "deactivated."

In the latest run, performed with Viking lander 1, team leader Norman Horowitz of the California Institute of Technology decided to use a soil sample that was first moistened, then heated to drive off the added water. With both of the response-lowering techniques in use, he reasoned, the data should almost surely yield a zero. Instead, the instrument showed a "first peak" radioactivity count of about 2,200 and a significant second peak of 32. "As far as we're concerned," says Frederick Brown of TRW, Inc., "that's a positive response."

Combined with past runs, says Brown, the result shows that "if you add water, the response goes away; if you remove the water, it returns." More important, he says, is that it seems to be a vote against biology, since the preheating would presumably have "deactivated its response" more readily than it would have affected a nonbiologic reaction.

These same results, however, raise a serious problem, according to Gilbert Levin of Biospherics, Inc., another of Viking's chief biologists. The "gas-exchange" experiment in Viking's biology package showed early in the mission that exposing a soil sample to moisture (in the form of water vapor given off by a nutrient solution) produced a rapid release of oxygen that suggested to some observers the presence of substantial amounts of peroxide or superoxide adsorbed or otherwise trapped on the soil grains. The release was so complete, in fact, that adding more water a few days later (by bringing the sample into physical contact with the nutrient) produced no more oxygen. The possibility of such volatile oxides, while by no means proven,