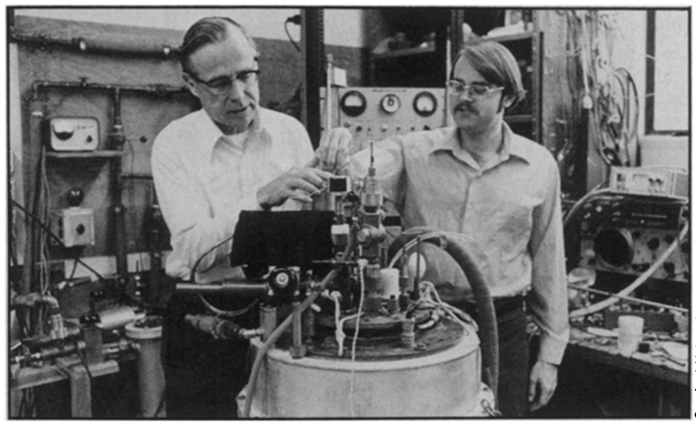
Evidence for Fractional Electric Charge

Ever since Robert A. Millikan first began to try to find the electric charge of the electron, physicists have been measuring and remeasuring the charges of subatomic particles and larger bodies. Until now no one has been willing or able to conclude that an electric charge could exist that was not equal to the charge of an electron or some integral multiple of it. It seemed a basic fact of nature that electric charge was quantized and that the basic quantum was the amount of the electron charge.



Fairbank and LaRue adjust the cryogenic refrigerator in which they levitated niobium balls that may have had unbalanced quarks stuck to them.

Stanford University

This week at the meeting of the American Physical Society in Washington, two physicists from Stanford University, William M. Fairbank and George S. LaRue, told a crowd that had literally crawled through the walls of the room (the folding partitions of a hotel ballroom) to hear that they had, in LaRue's words, "evidence for fractional charge." The evidence results from 12 years of work by Fairbank, LaRue and a third physicist, Arthur F. Hebard, now of Bell Telephone Laboratories. The result, if it is confirmed—and the next thing Fairbank and LaRue intend is to do a further series of measurements and to try to isolate the fractional charge from the ball and see what it is—is likely to stand as one of the most important experimental results in physics of this or any century.

In the seven decades or so since Millikan flourished, many experiments have been done to check the value of the charge quantum, which is an extremely important number for theoretical and experimental physics as well as many branches of technology. Some of those experimenters have occasionally seen data that looked strange, but they have been unwilling to place any reliance on them. Millikan himself recorded that he threw out one piece of data that seemed to indicate a measurement of about 0.30 of the electron charge because he could not quite believe it. Fairbank, LaRue and Hebard are the first who have the nerve to stand up and tell a room full of physicists that they believe such a result, although Fairbank is quoted in an announcement by Stanford University to the effect that "this discovery is tentative."

The basis of the experimental technique is in general the same as those of the many preceding experiments. One does not try to use individual electrons to measure. One takes a small piece of matter, in Millikan's case an oil drop, in others, a small ball of metal, and levitates it in electric or magnetic fields or both. The electric charge on the drop or ball is gradually reduced until it can be reduced no more. The charge can be measured by how much electric force is necessary to make the ball float against gravity. The trick is to measure zero charge and then the nearest thing to zero that the ball will sustain.

In the Stanford case, the balls were of superconducting niobium and were 0.025 centimeters in diameter. Their charges were gradually reduced to zero by bombardment with electrons and positrons. Measurements of eight such balls yielded two instances in which the result was different from zero or one. One such seems to be about minus one-third of an electron charge, the other plus one-third. In one of these cases, LaRue says, subsequent measurement on the same ball gave a reading of zero, as though there had been a one-third charge on the ball that had later gone away.

The number one-third is highly suggestive. A well regarded theory says subatomic particles are built of subparticles called quarks. One version of this theory envisions quarks that have charges equal to one-third and two-thirds the electron charge. So a possible interpretation of the result, which is mentioned in the Stanford announcement, is that somehow an individual quark that did not form part of a subatomic particle had attached itself to the surface of the ball. Neither Fairbank nor LaRue explicitly made such an interpretation in his presentation, but many in the audience drew the conclusion. One question from the audience was: "How many free quarks per nucleon in the ball would that result make?" LaRue replied: "One in 5×10^{19}."

The major difficulty with an experiment like this, and the main reason this one took 12 years, is that there are a host of background forces and disturbances, electric, magnetic, thermal and even seismic, that can foul up the measurements. Many of the odd results recorded in the past have been attributed to such disturbances. The burden of Fairbank's talk was to convince the assembled colleagues that the background had been either eliminated or properly discounted. The two talks were greeted with loud applause, but the applause was followed by a rapid fire of sharp questions about the background forces, the techniques of measurement and the data analysis. At this point it is not clear whether the questioners were believers seeking reassurance, skeptics trying to poke holes or a mixture of the two. The majority response as the news spreads through the physics community will tell.

If the result of Fairbank, LaRue and Hebard stands up, and if it indeed involves loose quarks, it will reopen a number of important questions in the quark theory and also possibly some old lacerations in the hides of theorists. Up to now, theorists had just about convinced themselves that free quarks were impossible, that there were reasons involving the laws of their nature that prevented them from ever separating out of the structures of the particles they build. As R. R. Freeman of Bell Laboratories, who chaired the session, said in introducing Fairbank, "[He] will tell us how to get out of the bag, off the string and on the ball." The bag and the string are two analogies for the ways theorists have thought up to explain why quarks appear to be eternally stuck inside the structures they build and inherently unfreeable. □

A Martian muddle: DNA the dry way?

In the many months since the Viking spacecraft began reporting from the surface of Mars, only a single unified proposal has publicly emerged to attempt to account for the seemingly conflicting data from the landers' biology instruments. Developed by Vance Oyama of NASA's Ames Research Center (SN: 3/5/77, p. 149), it has so far achieved neither acceptance—nor competition. Now Oyama has dramatically extended his hypothesis: Although he believes that the Viking instruments have shown no signs of living