A Quantum Number Whose Time Has Come

Modern physics began with quantum numbers, characteristics of physical systems that change only by discrete integral amounts rather than in the smooth continuous way of classical physics. The first quantum numbers that appeared in atomic physics concerned qualities familiar from macroscopic physics such as electric charge or angular momentum (spin). Today there are many others, and the existence of the latest to be hypothesized, charm, seems now overtly proven.

With quantum numbers went conservation laws. Conservation laws specify that in any activity of the physical system (such as radioactive decay or various collisions and what comes out of them) the total amount of the given quantum number must be conserved (or may change only in certain circumstances under strict rules). Conservation laws are an inheritance from classical physics. In that realm both charge and angular momentum are absolutely conserved.

It was difficult enough to understand why old familiar things like electric charge or angular momentum, which could change continuously in the macroscopic world, suddenly turned into quantal jumpers when the boundary of the atom was pierced. But then the real fun began. As physicists discovered more and more "elementary" particles that behaved in many complicated ways, they had to invent ever newer and more exotic quantum numbers and conservation laws to sort out permissible from impermissible behavior. Some of these were named for a physical connection (for example, isotopic spin, which refers to differences among isotopes of the same system); some are arbitrary or even whimsical, like charm, whose hour now seems to have struck in two different laboratories.

Charm came into theory in the usual way to explain why certain decays, permitted under all the previous rules, were not seen. Like most changes in theory, charm brought new predictions in its train, and experimenters began to look for these. For more than a year, since the discovery of the psi particles in November 1974, physicists have suspected that charm was responsible for anomalies in the behavior of these new and exotic objects. But the psi's were viewed as combinations in which charm and anticharm balanced each other and were therefore not overtly detectable. To clinch the case, particles were needed that displayed unbalanced, overt charm. These now seem to have been found in three events recorded at the CERN laboratory in Geneva and four more at the Fermi National Accelerator Laboratory near Batavia, Ill.

The work concerns the interactions of neutrinos in bubble chambers. All of FermiLab's four events yield a negatively charged muon, a positron and a neutral K meson. The crucial point is that the muon and the positron belong to the class of particles called leptons and the K meson possesses the quantum number called strangeness. Charm was invented to explain certain anomalies in the behavior of particles with strangeness, and this kind of a decay, yielding two leptons and a strange particle at the same time, is the sort theory would expect from a particle with unneutralized charm. The three CERN events are exactly the same as FermiLab's four, and the conclusion there is the same. CERN's statement even refers to this "as a new process of nature."

Apparently the neutrino, striking a neutron or proton in the bubble-chamber liquid, produces the new charmed particle, and that then decays into the products recorded. From the energies of the positron and K meson, the FermiLab people estimate the mass of the new particle at twice that of the proton (approximately two billion electron-volts), and from the virtual lack of any flight space for it in the pictures, they believe its lifetime should be less than 10^{-13} seconds.

The introduction of charm into theory required an important amendment to the decade-old quark theory of the structure of particles. The theory had held that the properties of the particles could be understood if they were regarded as various permutations of combinations of three basic subparticles called quarks and three basic antisubparticles called antiquarks. Charm requires the existence of a fourth, charmed, quark and a fourth, anticharmed, antiquark. The psi particles are regarded as containing within themselves pairs of the charmed and anticharmed quarks. Thus, although they do not exhibit charm overtly, it does influence their behavior. The new particles now reported by CERN and FermiLab seem to contain an unbalanced charmed quark and may be the first of a whole new series.

The rarity of the events should be stressed. The CERN statement refers to one of CERN's events as literally one in a million pictures. Particle physicists are used to having thousands or millions of events on which to base arguments. Three or four make them very cautious.

So news of this kind transpires slowly and painfully. (If there were ever an accurate use of "transpire," this is it.) At first a few close colleagues are informed confidentially. Then the circle of those in the know is widened. Eventually, a statement may be made by the way at a meeting, or a carefully worded paper in which the real discovery is treated in a throwaway line is published as a trial balloon. If by now the proponents have not been flattened by the critics' artillery, they may venture a formal claim to discovery. The only literature reference for this affair so far is a paper referring to one of the events published in PHYSICS LETTERS (58B:361) by 54 physicists from all over Europe working at CERN.

These days physics seems to have completed a kind of circle. In Newton's day there was a certain specificity about it. There is, after all, only one moon, and from its behavior Newton was rash enough to generalize the whole universe. As physicists began to study large aggregates of similar bodies, gas molecules, for example, statistics and statistical laws came to the fore. In atomic and particle physics statistics became intrinsically necessary because of a built-in uncertainty about what any individual particle would do. Now it seems we are back to the point of supporting universal theories with very few instances. □

Ethiopian fossils: The way we were

When and where are pretty well settled. Now it is time to concentrate on what. That question has to do with the earliest true humans, the genus *Homo*. Recent finds reported by Richard E. Leakey, Donald Carl Johanson and Mary Leakey (SN: 11/8/75, p. 292) have all placed *Homo* in East Africa at least three million and possibly four million years ago. This week another fossil find was reported. It confirms the place and time and adds to the growing body of knowledge of what our ancestors were like.

The find—bones of two infants and three to five adults—was made by Johanson of the Cleveland Museum of Natural History and Maurice Taieb of France's National Center for Scientific Research. Their work, sponsored by the National Geographic Society, was done in the Hadar region of Ethiopia.

The site of the find is a sharp, narrow slope that may once have been on the shore of a lake. The volcanic soil in which the fossils were found was tested by Taieb, a geologist, and confirmed to be more than three million years old. A previous find by the researchers in the same area could not be as well dated and was only estimated at three million to four