physical sciences

From our reporter at the 16th International Conference on High Energy Physics at the University of Chicago and the National Accelerator Laboratory

K^0 decays and unitarity

One of the most fundamental principles of physics is the conservation of matter-energy, which says that matter and energy can neither be destroyed nor created in the course of physical processes.

From this physicists who study the decays of unstable particles have developed the so-called unitarity principle. It says that if a particle can decay by several modes, the sum of the fractions taking each particular mode should add up to one. For something over a year particle physicists have been concerned that they were seeing a contradiction of this unitarity principle. The culprit is a meson called K-zero-long. Theory predicts that this meson should occasionally decay into a muon and an antimuon. A group from the University of California at Berkeley had reported that they had not seen any of these two-muon decays even though they believed their experiment sensitive enough to find them.

The result sent theorists scurrying to work, because neither of the alternative explanations is attractive. Either some K mesons were disappearing without a trace or something was seriously wrong with theoretical attempts to understand the weak interaction, which governs decay of the K meson.

At the Chicago-NAL meeting a group from the University of Heidelberg and the CERN laboratory in Geneva reported that they had found the two-mu decay. Everyone at the meeting seemed relieved by the announcement. Nevertheless one positive and one negative result do not prove the case and more experiments are necessary. But as Murray Gell-Mann of Caltech puts it: The theorists can now step aside and let the experimenters argue about the existence of the two-muon decay.

Conservation of electrons

As particle physicists sort through the data they have gained, they often discover conservation laws. For example, the observation that the total electric charge on one side of a collision or decay is always equal to that on the other leads to the law of conservation of charge.

The electron is supposed to be an absolutely stable particle; no evidence of its radioactive decay has ever been seen. One of the consequences of this is a law called conservation of electron number. Each member of the electron's family, so to speak, is assigned a number, one for the electron and the electron neutrino, minus one for the positron and the electron antineutrino. It is observed that in all recorded processes involving these particles the sum of electron number is the same on both sides of the process.

A disproof would be an attack on electron stability that could have serious repercussions in atomic physics and chemistry as well as in particle physics. A group of European physicists set up an experiment in a tunnel under Mont Blanc to test out the law in the process of nuclear double beta decay. In that event a germanium 76 nucleus becomes selenium 76, emitting two electrons and two electron antineutrinos. By measuring the energies of the electrons one can tell whether conservation of electron number is violated. E. Fiorini of the University of Milan reported that the law is still valid. The evidence in hand rules out violations at any rate better than once in 2.5×10^{21} years.

A new rho particle

In a colliding-beam experiment a great deal of the energy brought in by the beams is available to generate the mass of new particles. Physicists are looking mainly to the proton-proton clashes for either surprises or confirmation of old theories, but it is the electron-positron ring, Adone, at Frascati, Italy, which seems to have found one.

C. Mencuccini of Frascati reports that some of the events studied give evidence of a possible rho-prime meson. The particle would have a mass of 1.6 billion electron-volts, but would otherwise have the same quantum numbers as the known rho-zero. In some theories the rho-zero plays an important mediating role in interactions between photons (gamma rays) and neutrons and protons. What role the rho-prime may play is unknown, but its two apparently observed decay modes both include a rho-zero.

Testing quantum electrodynamics

Quantum electrodynamics is the theory of electromagnetic processes at the particle-physics level. Although all of its problems have not been solved, QED is the best understood and most elegantly formulated of the theories of microscopic physics. The theories of the strong nuclear and weak interactions are in much worse shape. Physicists have great confidence in QED, but they still wonder whether it will hold at high energies.

The Adone storage ring in Frascati can accelerate beams of electrons and positrons to several billion volts each and bang them together. The resulting high-energy annihilation reaction is a very fine test of QED. A group from the University of Bologna, CERN and Frascati examined what came out of these collisions. A. Zichichi of Bologna reports that the results were as predicted by QED, and the theory is still valid at these energies.

No quarks in the ISR

The Intersecting Storage Rings at the CERN laboratory in Geneva can take beams of protons from the CERN proton synchroton at energies up to 30 billion electron-volts (30 GeV) and collide them. Nearly all this energy is available for the formation of particles. (An accelerated beam striking a stationary target would need more than 1,000 GeV or 1 tera-electron-volt to equal it.)

Many physicists hoped that the ISR would produce a quark. So far it has not. B. Hyams of CERN reported on a search involving recording equipment that should have been more than 90 percent effective in detecting quarks with either one-third or two-thirds of an electron's electric charge. No signals survived the scrutiny designed to filter out records of other particles that might look like quarks.