SCIENCE NEWS OF THE WEEK

Life among the leptons: Yet another new particle?

In a pipe on the grounds of the Stanford Linear Accelerator Center located among the purple-golden grasses and scrubby trees of California's coastal mountains, two leptons come together. They are electron and positron, equal pieces of matter and antimatter, carrying equal energy, traveling in opposite directions. The place of their meeting is the center of a complicated array of particle-detection equipment that is *the* experiment at the SPEAR storage ring facility, and is operated by a consortium from SLAC and the Lawrence Berkeley Laboratory.

When electron and positron meet, they annihilate each other, producing a virtual photon, an object that is matter, antimatter and light at the same time. The virtual photon exists for a fleeting twinkle of the Heisenberg uncertainty principle, and then turns itself into all manner of wonders, depending on the energy it possesses. The procession started when the total energy reached 3.1 billion electron-volts (3.1 GeV). There have been a couple of other stages on the road, and now, at an energy slightly above 4.0 GeV, something new is happening again, Martin Perl of the SLAC staff announced this week.

The physicists don't see the wonders directly. The wonders are much too short-lived for that. What they see are the stabler particles that are produced in the radioactive decay of the wonders, and from these they try to infer the characteristics of their parents.

What is seen at 4 GeV is a sudden rise in that rate of detection of electrons and muons that presumably comes from the decay of something made at that energy. In itself, this is surprising, because if the 4 GeV are going mainly into the mass of a new particle, that particle, by all the proprieties of particle physics, ought to be associated with the strong nuclear interaction and to produce particles such as protons or neutrons or various mesons or hyperons. It doesn't. It yields instead only particles associated with much weaker forces, those of the weak or electromagnetic interaction.

The working hypothesis in this case seems to indicate that a pair of new particles is produced. Perl refers to the pair temporarily as U particles because their nature remains yet unknown. He proposes that one of them is electrically positive, the other electrically negative. They both would have the same mass, something between 1.6 and 2.0 GeV. After a very short life, they decay, one of them producing an electron and the other a muon. It is these that the detectors record. Still, half the energy has gone somewhere else, and since the detectors do not record electrically neutral particles, it must be invested in neutrals, most likely neutrinos.

There are two suggestions about the nature of the U particles. One is that they may be heavy leptons. So far there are only four known leptons: the electron, the muon and the neutrino associated with each of those. They are the particles that do not respond to the strong interaction, being intimately involved with the weak interaction instead.

Addition of a heavy lepton to the family—the known leptons are the lightest of all particles except the photon—would have important effects on the theory of the weak interaction. New formulations have arisen that unite that interaction with electromagnetism in a unified—or at least partially unified—field theory. One of the predictions of the unified theories is the existence of heavy leptons. The unified theories have been supported by experiment at other points (SN: 5/4/74, p. 284), and the addition of heavy leptons would be both welcome and necessary for increased confidence in them.

The other hypothesis about the U's is that they are particles possessing a newly hypothesized quality called charm (SN: 1/25/75, p. 58), and are related to the psi particles already discovered at 3.1 and 3.7 GeV in the same and other experiments. The heaviness of the U's would explain why the psi's have anomalously long lifetimes for particles so massive.

According to theory, a psi should be made of one quark possessing charm and one possessing anticharm. The quick way for the psi to decay is into two particles, one charmed and one anticharmed. But if the U's are the lightest such particles—and none lighter have yet been seen—it may not be possible for the 3.1 and 3.7 psi's to do so. The masses of the U's, in pairs or singly, may be more than 3.1 or 3.7. Nothing can decay into something heavier than itself, so the 3.7 or the 3.1 or both must find more difficult, rare means of decay, not involving particles overtly exhibiting charm, and so they live longer.

If either hypothesis about the U's is true, their discovery is one of the most important yet racked up in the electron-positron collision business. Reports from other similar experiments are eagerly awaited. ☐

The sun's acoustical reverberations

Earthquakes can sometimes make the whole earth ring like a bell. Acoustic waves travel through the whole bulk of the planet. For decades theorists have wondered whether such things might happen on the sun too as a result of the violent events that occur on its surface. A physicist from the University of Arizona, Henry A. Hill, now reports that such solar reverberations do in fact occur.

Hill's experiment began as an attempt to find out whether the sun's shape is oblate. Oblateness in the sun is important to rival theories of general relativity or gravitation, since it would discredit Einstein's formulation and open the way to others. Hill designed special equipment to observe the edge of the sun and determine if there was any bulge.

Hill has reported that he found no oblateness, but on the way he did observe fluctuations in brightness at the edge of the sun. These, he now says in an announcement this week by the National Science Foundation, are a vehicle to detect oscillations, waves running through the sun. The waves are acoustic or mechanical waves, physically equivalent to sound or seismic waves in the earth.

Oscillations at several frequencies occur simultaneously, the slowest yet seen taking about 50 minutes for a cycle. The observations agree well with theoretical calculation of what the sun's acoustic modes should be, Hill says, and they will be a good test of models of the solar (and stellar) interior and its connections to surface events.

The oscillations also may explain why the flux of neutrinos from the sun expected by theory is not seen. The acoustic waves carry energy out of the sun, and they do it fast. A given bit of energy traveling from the center to the surface would take 30 million years if it moved in the form of light. (The solar interior is extremely opaque and the light would undergo countless absorptions, re-radiations and scatterings.) Invested in the acoustic waves, the energy gets out in 25 minutes. With the waves present, the interior may be too cool for the main neutrino-producing cycle, that involving boron nuclei. Eighty percent of the expected solar neutrino flux is supposed to come from this process, the rest mainly from a cycle involving protons. If the boron cycle is not happening, that may explain why Raymond Davis Jr. of Brookhaven National Laboratory is having such trouble finding neutrinos with detectors he has set up in a mine near Lead, S.D. ☐

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