J (or psi): A surprising new particle

To add to the present ferment and confusion in particle physics nature now presents the oddest new particle to turn up in many years. Experiments have consistently failed to find particles that theory predicts. But suddenly two experiments at opposite ends of the United States have turned up a particle that is probably not one anybody was looking for. Theorists are at a loss for the moment about what to do with it.

The discovery was made simultaneously at Brookhaven National Laboratory in New York and at the Stanford Linear Accelerator Center in California and is now reportedly confirmed by work at the Deutsches Elektronen-Synchrotron in Hamburg and the Frascati laboratory near Rome.

The new particle is the heaviest yet found, weighing in at about 3.1 billion electron-volts, more than three times as heavy as a proton. It stands outside of the two classes of subatomic particle, being neither hadron nor lepton. In this it bears an analogy to the photon or light particle, and the similarity goes even further: The new particle appears to be a vector particle, one of the particles that embody a particular force and carry it from place to place. Specifically there is a hint that the new particle is one of the family of intermediate vector bosons, the particles that theory expects to carry the force of the weak interaction. (The weak interaction is the least understood of the four kinds of natural force known to physicists; its intermediary, long sought, has never yet been found until maybe now.) It is true that most recent theoretical estimates of the boson mass start at about 10 times the mass of the new particle, but that, says Samuel C. C. Ting of Massachusetts Institute of Technology, leader of the experiment done at Brookhaven National Laboratory, is largely because nothing resembling the boson has up to now been found at lower mass levels.

The new particle has still another important anomaly, its lifetime of 10^{-18} seconds. That may not seem very long, and it is too short to catch the particle directly, but it is long for a particle of that mass. There must be some unheard of kind of structure to keep the particle together for so long. What that is, is likely to provide good exercise for theorists for some time to come. The new particle is electrically neutral. It apparently has spin one and negative parity. It is being called J on the East Coast and (lower-case) psi on the West. Which name will prevail remains to be seen.

The two American experiments are in a way reverses or mirror images of each other. The one at Brookhaven was an MIT-BNL collaboration including, beside Ting, U. J. Becker, Min Chen and others of MIT and Y. Y. Lee of BNL. It started with a collision of two protons (which are hadrons) and ended with pairs of electrons and positrons. The SLAC experiment was a SLAC-Lawrence Berkeley Laboratory collaboration including Burton Richter, Roy F. Schwatters and Rudolf R. Larsen of SLAC and William Chinowsky, Gerson Goldhaber and George H. Trilling of LBL. It started with collisions of electrons and positrons in SLAC's SPEAR storage ring and ended with hadrons. In both cases the new particle appeared in the middle, created by the initial particles and decaying into the final ones. Details of these and the Hamburg and Frascati experiments will appear in the Dec. 2 PHYSICAL REVIEW LETTERS.

The discovery moves particle physics into a new realm of masses and properties. "The suddenness of the discovery, coupled with the totally unexpected properties of the particle are what make it so exciting," says Ting. "It's not like any particle we know; it must have a new kind of structure." The discovery wasn't easy. Only recently has SPEAR been able to dispose of the necessary energy. The Brookhaven experiment, says Ting, was very difficult. It took eight years to plan and set up. The physicists began to see the particle in August. Now they have about 500 recorded.

The physicists are now going to see whether nature has more particles like the psi-J. Ting speaks specifically of looking for electrically charged analogues. (If the psi-J is the intermediate boson, theory would want them.) Another possibility his group will look for is a neutral doublet to the psi-J at a slightly different mass. □

FermiLab's powerful electron zing

The Fermi National Accelerator Laboratory (FermiLab) now has the most energetic beams of all the probe particles that physicists like to use in studying the fundamental structure of subatomic matter. In was built to accelerate protons to the highest energies yet artificially achieved, and it does so—to 400 billion electron-volts (400 GeV) now and to 500 GeV soon. Using this capability, the laboratory has derived the most energetic beams of neutrinos and various kinds of mesons. On Nov. 13 it rounded out its capabilities by producing the world's most energetic electron beam.

The new beam already yields electrons at 200 GeV, and it may go as high as 300 GeV. Previously the world's most energetic electrons were produced at the Serpukhov laboratory in the Soviet Union at an energy of 45 GeV. The best available in the United States was 20 GeV at the Stanford Linear Accelerator Center.

The sequence that produces the electron beam begins by focusing protons from the main accelerator onto a bar of beryllium. The collisions of protons and beryllium nuclei produce a lot of nuclear fragments, but of interest here are pi mesons. The pi mesons decay into photons. The photons then strike a lead plate to produce the electrons that make the electron beam. It took a year and $2 million to build the electron beam. A group of FermiLab staff led by physicist Thomas Nash did the work.

The first major use of the new beam will be not experiments with electrons directly but with photons made as the electrons strike a second lead plate. (Why not use the original photons back before the electrons? Their energies are uncertain. Making photons from electrons, physicists can measure the energy of the recoil electron after it emits the photon. They then know the energy of the photon. Thus the facility is called the Tagged Photon Laboratory because each photon is "tagged" with its particular energy.) There is much interest right now in what happens when extremely high-energy photons strike matter. It has an important bearing on physicists' attempts to unify their theories of the forces and structures fundamental to the world of particles. Just for comparison, visible-light photons have energies of a few electron-volts; X-ray photons may have 100,000 electron-volts. Some in the FermiLab beam are in excess of 100 billion electron-volts. It's quite a zing, and it should find things out. □