

And another?

At the New York meeting of the American Physical Society in February a Columbia/Fermilab/Stony Brook team, lead by L.M. Lederman, presented evidence for the existence of a particle which they have called Upsilon. The fascination of this new object lies in the fact that it is the heaviest yet seen (around 6 GeV) and is surprisingly stable.

The team was looking at the production of electron-positron pairs from a beryllium target hit by 400 GeV protons from the Fermilab accelerator. The experimental technique is very similar to that used by the Brookhaven/MIT team of S.C.C. Ting in unearthing the famous J particle at 3.1 GeV. Sifting out electron-positron pairs from the spray of particles emerging from a bombarded target is experimentally very tricky but, like Sam Ting's team at Brookhaven, Leon Lederman's team at Fermilab have several years of experience at this difficult game. The Columbia contingent, for example, was busy studying 'heavypotons' at Brookhaven in 1968.

The detection system, installed in the Proton Center Laboratory at Fermilab, consists of a double arm spectrometer symmetrically positioned at the target. The arms are identical and each consists of a collimator, a magnet, scintillation trigger counters, multi-wire proportional chambers, scintillation hodoscopes and, finally, a lead/lead glass calorimeter which is the main detector for electron identification and energy measurement. The aim of the experiment was to search for high mass particles extending beyond the mass range which is available to the MIT/Brookhaven team and the IISN/IPN Orsay team at CERN. The Fermilab experiment can scour the mass region from 2.5 to 20 GeV.

When an electron and positron are spotted and their properties measured, it is straightforward to calculate the mass of the object from which they

could have emerged. If the same mass occurs repeatedly, it is likely that a particle of that mass exists, one of the ways in which that particle can break-up being to produce an electron and a positron. This was the route to the J particle — measurements on the emerging electron and positron repeatedly added up to an object of mass 3.1 GeV.

Moving to higher energies, the probability of seeing electron-positron pairs is expected to fall rapidly. For example, one theory predicts that at 10 GeV there will be only one heavy photon which can give an electron-positron pair for every 10 000 heavy photons at 2 GeV. Even at 2 GeV such a photon crops up only once in a million interactions in the target. This underlines how difficult it is to extend the search to higher energies.

The search began in the summer of 1975 and the equipment was tamed so that good data could be taken from about Autumn. The 3.1 GeV particle was seen clearly. The first interesting observation was that the electron-positron pairs were considerably rarer than expected. They were seen at a rate of about one every two days with 5×10^9 interactions in the target per pulse.

By the time the preliminary findings were made known in New York, 27 events in the 5.5 to 10 GeV range had been measured. The excitement comes from the fact that eleven of these events cluster between 5.8 to 6.1 GeV. The experimenters estimate that there is a 50 to 1 chance that this means a particle of mass 5.97 GeV which can decay into an electron-positron pair.

It also looks as if the particle, called Upsilon, is surprisingly stable. Such a heavy object should have so many ways in which it could break up, that it should not hang around for long. Something special about its properties would be needed to ensure long lifetime. This recalls the J/ ψ story

again. The high stability of the 3.1 GeV particle is assumed to be the result of a special property known as charm. J/ ψ cannot easily get rid of charm and hence is highly stable. The charm property is assumed to be carried by a new type of quark — charmed quark.

If Upsilon is confirmed and its stability is high, what is the cause this time? Is charm appearing again in some other combination? Do we need another property to explain Upsilon? Will this imply yet another quark? We have already had a hint that our list of leptons might have to grow beyond four with evidence for a new heavy lepton at the Stanford SPEAR storage ring. Is this a hint that our list of sub-hadrons (the quarks) might also have to grow beyond four?

The evidence for Upsilon is impressive but needs more bolstering before any of these questions can be seriously tackled. The team at Fermilab may switch over to the detection of muons in the spectrometer arms, looking for the Upsilon decay into a positive muon and a negative muon. This decay is expected to occur at a rate some 5 to 10 times higher than the electron-positron decay but it can be even more difficult to sort out from the background. Another help towards increasing the rate is that a forthcoming reshuffle in the Proton Center Laboratory should give the experiment 100 times the present proton intensity onto their target.

More information is eagerly awaited because the evidence for Upsilon has already given the melting pot another good stir.

Members of the team are David Hom, Leon Lederman, Hans Paar, David Snyder, Jeffrey Weiss and John Yoh from Columbia University, Jeffrey Appel, Bruce Brown, Charles Brown, Walter Innes and Taiji Yamanouchi from Fermilab, and Dan Kaplan from Stony Brook.