# news and views

## A new stable particle: is charm appearing?

INTENSE interest has been aroused by the observation of a new particle with a mass of 3.1 GeV/$c^2$. Claims from Brookhaven, New York, where it is called the J meson, and from Stanford, California, where they call it the $\psi$, agree so far on its major physical properties. The Massachusetts Institute of Technology group led by Sam Ting has seen a very sharp peak in the mass spectrum of $e^+e^-$ pairs, produced when a beryllium target is exposed to the 29 GeV/$c$ proton beam from the Brookhaven Alternating Gradient Synchrotron. The peak is only about 5 MeV/$c^2$ wide, which is consistent with the resolution of the apparatus, and its production probability is about $10^{-7}$ times the probability for producing strongly interacting particles (hadrons). A Stanford-Berkeley group led by B. Richter used the Stanford electron-positron storage rings 'SPEAR' to produce the new particle directly by $e^+e^-$ annihilation. They claim that its width is less than 1.3 MeV, and that it decays to hadrons, to $e^+e^-$ and probably to pairs of muons. In contrast to the low relative probability for producing the particle with protons. the electron-positron interaction probability is enhanced by a large factor as a consequence of $\psi$ (or J) production.

It is clear from the way that the particle is produced that it does not couple strongly to the normal hadrons—the proton and neutron, the hyperons, the pion and kaon, and so on. If it did, then its production rate at Brookhaven should have been much greater. The relatively large production rate at Stanford implies that the $\psi$ (or J) couples to $e^+e^-$ by a simple (lowest order, single photon) electromagnetic process. Weak interactions, as understood at the moment, could not account very easily for the Stanford results.

A particle without strong decays is usually regarded as 'stable', and a width of less than 1.3 MeV/$c^2$ implies a lifetime of more than $10^{-21}$ seconds—a long time on the strong interaction scale. If the $\psi$ (or J) carries only known quantum numbers then it is very hard to see why it should be stable. With 3 GeV of decay energy available it is possible to imagine hadron final states with almost any combination of quantum numbers. As long as such final states can exist, then we would expect strong decays of the $\psi$. Electromagnetic decays do not conserve as many quantum numbers as strong decays do. That is why the well established eta meson can decay electromagnetically into three pions, for instance, even though the conservation laws forbid a strong transition from eta to three pions.

Three of the possible explanations for the $\psi$ deserve mention. The obvious first hypothesis is that it carries a new quantum number which is conserved by strong interactions but is not conserved by electromagnetic processes. This cannot be ruled out, but it is an uneconomical theory since it requires a totally new quantum number to be invented specially to explain this one finding. A second hypothesis is that the $\psi$ is the intermediate boson which carries the weak neutral current (the intermediate vector boson is a heavy particle, probably as heavy as 40 proton masses, which carries the weak interaction; see *Nature*, **250**, 186; 1974, for the present status of experiments on weak neutral currents). But if the boson mass is only 3 GeV/$c^2$ we would expect very large differences between the properties of the neutral currents as observed in the CERN Gargamelle experiments with 5 GeV neutrinos and in the Fermi Laboratory experiments with 100 GeV neutrinos. No significant differences have been seen. The third and most elegant hypothesis also incorporates a new quantum number, but one which has already been suggested to explain the absence of strange particle production in neutral-current processes. The $\psi$ may be inhibited from strong decay because of 'charm'; not because the $\psi$ itself is a charmed particle, but because it is made of a charmed quark and a charmed antiquark.

Another well established meson, called the phi, also has electromagnetic decays to $e^+e^-$. It is not quite a stable particle—it decays by the strong interaction to a kaon plus an antikaon—but it chooses not to decay by the far more accessible channel to three pions. The omega meson, which has all the same normal quantum numbers as the phi, and is lighter than the phi, decays very rapidly to three pions. The absence of a phi to three pion decay has been explained very convincingly by saying that the phi is made from a strange quark and a strange antiquark. In a decay process the strong interaction apparently preserves the quarks that were contained in the decaying particle. The lightest particles which contain strange quarks are the kaons, so the phi either decays to a kaon-antikaon pair, or it decays electromagnetically. If the kaons just happened to be about 10% heavier than they are, then the phi would not be able to decay into them—its mass is 1.018 GeV/$c^2$ and a kaon has a mass of about 0.49 GeV/$c^2$.

Perhaps the $\psi$ is a similar object to the phi. Charmed mesons may exist, like the strange mesons we call kaons, but if the lightest of them is more than half the mass of the $\psi$ then the $\psi$ will not be able to decay into a pair of them through the strong interaction.

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## Misunderstandings over $C_4$ carbon fixation

ECOLOGISTS concerned with energy flow in ecosystems, and particularly those interested in primary energy fixation, await a clarification of the status, both in energetic and ecological terms, of the recently described $C_4$ pathway of carbon fixation found in certain angiospermous plants. At present the literature presents a rather confused picture. Statements now proliferate which give the impression that there are "two major photosynthetic pathways of carbon assimilation in higher plants" (quoted from Osmond, *Aust. J. Bot.*, **22**, 39; 1974). Although such authors, and perhaps the initiates among their readership, may have a clear idea of what this means, to those unfamiliar with the biochemistry of these photosynthetic processes (which probably includes the majority of ecologists) the implication is that the so-called $C_3$ and $C_4$ plants have distinct and dissimilar methods by which carbon is assimilated into the plant tissue. In fact this is not quite true. Although $C_4$ plants possess a novel system for carbon concentration in