

meson exchange forces which make it difficult to form any bound state of two baryons other than the deuteron are expected to produce, on the other hand, a relative wealth of states which couple to the baryon-antibaryon system. Baryoniums also smooth out difficulties with the simple quark model in baryon-antibaryon reactions, where basic ideas of 'duality' seemed to break down (see June 1977 issue, page 197).

Experiments seem to show that there are two kinds of baryonium. Some states are broad, having typical hadronic decay widths of a hundred MeV or more, and are seen at 2190 and 2350 MeV in painstaking analysis of nucleon-antinucleon scattering data.

Other baryoniums have a much narrower width, usually of the order of tens of MeV, and are seen in selected channels of production experiments, such as the proton-antiproton pair in $\pi^- p \rightarrow p\bar{p}\pi^0$.

In the diquonium picture, these two kinds of baryonium are explained as being colour isomers with the same quark content but different interior colour configurations. Depending on this configuration either one or two quark pairs are formed when the colour tube connecting the diquarks snaps.

It is more difficult to produce two quark pairs than one, so the diquoniums producing two quark pairs will have a narrower decay width than those which produce just one pair. They will tend to emit mesons and change into other diquoniums.

However the diquark is only one simple example of a chromion, and whole ranges of new hadronic states could be formed from other chromions. Some narrow resonant states which have been reported could be explained as colour molecules built from two chromions, one containing three quarks and the other a quark-antiquark pair.

According to the ideas of colour

chemistry, these hadronic states are the forerunners of an infinite number of possible colour molecules. If so, this will provide fuel for many more years of experimental effort.

The solar neutrino problem

The puzzle of solar neutrinos has now been with us for some 20 years, but new technical developments afoot in the US and the USSR giving greatly improved capabilities for neutrino detection might soon resolve the problem.

It was W. Fowler and A. Cameron who first pointed out that the range of thermonuclear reactions in the sun's interior should produce an appreciable flux of neutrinos. These intense reactions provide the temperature which resists the immense gravitational forces trying to crush the sun, and the level of these reactions, as measured by neutrino fluxes, is a good thermometer for the sun's interior.

These neutrinos fly out through the sun and into space, some of them arriving on the earth. However observations so far show that the detected level of solar neutrinos is only a fraction of what is expected from theoretical estimates. If this is correct, it means that we do not understand well enough what is going on in the sun.

Solar neutrinos can be detected through a variety of neutrino-induced nuclear reactions, such as the conversion of chlorine-37 to argon-37. One of the pioneers of solar neutrino work, Ray Davis of Brookhaven, has built a neutrino detector consisting of a 100 000 gallon tank of dry-cleaning fluid (perchloroethylene) buried 5000 feet below the ground in a disused gold mine in South Dakota.

Results from this huge installation give results that are consistently less

than the predictions of various theoretical models, and moreover the results seem to be independent of the sun's position, showing that the recorded level might be due to some other source instead.

Theorists have tried to find ways out of the problem by tinkering with the parameters of the sun's interior, but these attempts appear to produce more difficulties than they remove.

One reason for the present impasse could be that the currently-used methods for neutrino detection have threshold energies which do not match well the spectra of the solar neutrinos. As a result, only the high energy tail of the neutrino spectrum is intercepted and the lower energy component of the flux remains undetected. To catch these more elusive but much more abundant neutrinos, other detection methods must be sought.

An example of such a method uses gallium-71, which is converted by neutrinos into germanium-71, but until recently it appeared difficult to extract the tiny amounts of produced germanium from the mass of gallium in the detector. However recent developments in the US now show how this can be done. All that remains is to find the money to purchase the gallium — some 15 million dollars would be required for a typical detector containing 50 tons of gallium.

In the USSR, a huge neutrino observatory in the Caucasus is now nearing completion. Among other things, this uses gallium detectors and should be able to identify solar neutrinos with much lower energies.

Asthenodynamics

In our July / August issue (page 246), we intimated that someone might come up with a name to describe the new unification of our description of the weak and electromagnetic interactions.