

periments are wrong, which now looks unlikely, or some other explanation is required.

The idea behind the bench-top experiments is that in a heavy atom (bismuth is being used at both Oxford and Washington), the atomic electrons spend enough of their time in or near the nucleus to be affected by the weak neutral force. Any parity-violating component in the interaction could rotate polarised light when passed through the atomic vapour, and sophisticated laser-based systems have been developed to detect any resulting rotation.

Calculations on the bismuth atomic structure based on the Salam-Weinberg theory suggest a rotation of the plane of polarisation by about 1.5×10^{-7} radians — an angle roughly equivalent to the width of a needle seen from five miles! Nevertheless with the help of laser equipment the Oxford group has established a sensitivity of 5×10^{-8} radians and the Washington group has reached 2×10^{-8} . No optical rotation by the bismuth atoms has yet been seen.

The apparatus is indeed so sensitive that even fingerprints, which contain large numbers of optically-active molecules, have a greater effect on the results of the experiment than any effect attributable to neutral current weak interactions!

One immediate objection to this negative result is that it hinges on a complicated atomic physics calculation to estimate the effect on atomic electrons due to nuclear interactions. Patrick Sandars of the Oxford group says that strenuous efforts are being made to improve the reliability of this calculation, but any larger discrepancy in the final result now seems 'unlikely'. Groups at both Oxford and Michigan are now proposing similar experiments using hydrogen where the atomic implications are much simpler.

Meanwhile high energy experiments at CERN, Fermilab and Brookhaven

have come up with some guideline statistics on neutrino and antineutrino scattering, and although the events are still pretty thin on the ground, it looks as though the cross-sections for neutral current interactions by neutrinos and antineutrinos are very different.

Although the isotopic spin structure of the neutral currents is still far from clear, this simple inequality shows that the neutral current cannot be of a simple vector or axial-vector form and, like its charged counterpart, must be a mixture of vector and axial-vector currents. The required vector and axial-vector mixture is as would be expected in a Salam-Weinberg picture. Mixtures of vector and axial-vector currents normally lead to non-conservation of parity, so why don't the atomic physics experiments see any violation?

One answer put forward by theoreticians is that the Salam-Weinberg model could be an oversimplification of what is going on. For instance the vector and axial-vector parts of the neutral current could couple to different bosons. This would preserve the vector and axial-vector structure of the current and the neutrino/antineutrino cross-section inequalities but could make the observation of any parity violation more difficult.

So far, neutral current interactions have only been seen in neutrino interactions and the negative result obtained by the Oxford and Washington groups underlines this. Any positive result by a bench-top experiment would not only measure the extent of parity violation attributable to the weak neutral current, but would also be the first sign of neutral current phenomena outside the neutrino arena.

Come Together

Whenever an experiment comes out with an unexpected result, the fertile

minds of theoreticians are further stimulated to revamp their existing ideas or come out with completely new ones. For example, when a few trimuon events were reported from Fermilab and CERN (April issue, page 95), it wasn't long before new mechanisms were put forward to explain the new phenomenon.

But now something else seems to be happening as well. Instead of picking on just one new observation, some of the biggest guns in theoretical physics are concentrating on producing a unified picture which accounts for a number of, at first sight, seemingly unrelated observations.

It has long been thought that the original Weinberg-Salam model of weak and electromagnetic interactions is an oversimplification of what is really going on, but opinions differ as to just where it is deficient. Each new embellishment would bring its own consequences — some wanted, some unwanted.

Rather than trickling in one by one, there now seems to be a bottleneck of new results in lepton physics. As well as the new, but still sparse, trimuon data, there are the details of dimuon events still to be explained. There is the evidence for new heavy leptons at SLAC and DESY. New experimental techniques still fail to detect any level of parity violation in atomic physics experiments. Details of neutrino scattering defy explanation by a simple quark model.

As a result, some authors are saying that the theory of weak and electromagnetic interactions needs a radical rethink to explain all these new observations in one go. Although the approaches taken differ widely, there seem to be two underlying common denominators — a proliferation of the number of quarks and leptons taking part in the interactions, and the introduction of 'right-handed' particles.

The proliferation of quarks and leptons is not necessarily a bad thing.