that while the positive discrepancy had disappeared, a small negative discrepancy of about 1.5 per cent remained. This discrepancy could only be explained if 'very heavy intermediate bosons' of mass M existed in the theory. Then the radiative corrections to β decay not present in muon decay gave rise to a term

$$-(3\alpha/\pi)\ln(M/m_p) \qquad (2)$$

where m_p is the proton mass, which removed the 1.5 per cent discrepancy for $M \sim e/G^{1/2} \sim 90$ GeV typical of electroweak theories. This result was for many years the only experimental evidence for the existence of the mass scale associated with the W and Z as Bailin and I have pointed out[9]. Bailin concluded that only when experiments can be made sensitive to effects of order $\alpha \sim 1$ per cent can the standard model be verified; this in itself demands a theory that can make definite predictions to this accuracy.

L. Baulieu (Ecole Normale Superiéure) then presented a paper which was a technical *tour de force:* he proved the renormalizability of the standard model on one transparency. He then showed the important result that for the measurable quantities (the so-called S-matrix elements) in the theory to be gauge invariant, the renormalization scheme used must define all its parameters on-shell. This property the standard model shares with QED where all S-matrix elements can be expressed in terms of the fine structure constant and the masses of the particles in the theory; it is unlike the situation in quantum chromodynamics (the present theory of strong interactions) in which all mass scales are arbitrary and renormalization is performed off-shell.

This result led directly to the appropriate definition of the electroweak mixing angle θ_W. Experimental papers take θ_W to be the mixing angle between the electromagnetic and weak neutral currents. This is a perfectly proper definition but one that leads to difficulties in a renormalization scheme since the weak current is normally defined at mass M_Z while the electromagnetic current is defined at zero mass. A. Sirlin of New York University (who first calculated[10] a radiative correction to a weak process back in 1956 and who has been the leading advocate of the importance of radiative corrections since unified electroweak theories were introduced) suggested with little dissent that Baulieu's on-shell approach required the natural definition of θ_W in the standard model to be

$$\cos\theta_W = M_W / M_Z \qquad (3)$$

using equation (1).

Salam was very keen that the workshop consider the question of the range of values of M_W and M_Z allowed in the standard model since he had just received a telex from CERN announcing the discovery of the Z of mass around 97 GeV. The question was answered by M. Consoli (Catania) and Sirlin who showed that even allowing a wide range for the unknown Higgs mass and the top-quark mass, there are strict limits on M_Z given M_W, regardless of the value taken for $\sin\theta_W$. The variation of M_Z with M_W was almost linear in this mass region and for a given M_W, M_Z was determined with error of less than 0.5 GeV. Sirlin stressed that it is preferable to eliminate θ_W altogether from this analysis, especially as $\sin\theta_W$ is determined in experiments where there are strong interaction corrections which are hard to quantify. He preferred to write down the direct relationship between M_W and M_Z in the standard model. This is

$$M_Z = M_W / (1-(A / M_W)^2)^{1/2} \qquad (4)$$

where A depends only on G(determined from the muon lifetime) and α. At tree level $A = 37.28$ GeV, but including radiative corrections $A = 38.66$ GeV.

The argument can also be reversed. From the experimental measurements of M_W and M_Z, A and hence the muon lifetime can be calculated; so if the standard model is correct, this procedure should be self-consistent. This is a very stringent requirement on the vector boson masses: for example, taking $M_W = 81$ GeV and $M_Z = 97$ GeV, a muon lifetime is obtained which is about double its actual value. Using the central value $M_Z = 95$ GeV of the UA1 report[11] still gives a muon lifetime about 50 per cent too long.

The primary test then of the success of the standard model quantitatively lies in the precise determination of the masses of W and Z to better than 1 per cent to see whether they are consistent with the muon lifetime using equation (4). If not, the model can be patched up — another Higgs can be introduced for example — but advocates of the view that the standard model simply provides an effective theory rather than the basic quantum field theory of elementary particles will be on stronger ground. ☐

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Ornithology

Discovery of a new albatross

from P. Jouventin and J-P. Roux

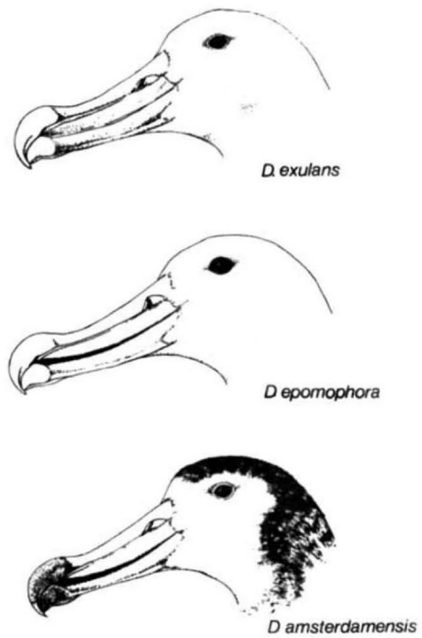
A NEW species of albatross has been discovered on Amsterdam Island, situated in the southern Indian Ocean midway between South Africa and Australia, and named Amsterdam Albatross, *Diomedea amsterdamensis*.

Several 'great albatrosses', presumed to belong to the species *Diomedea exulans* (Wandering Albatross), had occasionally been reported on the island. However, during a recent study it was realized that the population differed from the Wandering Albatross in several ways (see the figure).

The weight of the adult is nearly 3 kg less than in *D. exulans*; the breeding plumage is dark; the eyelid white instead of blue as in *D. exulans*; there is a decorative black stripe on the beak, as in the Royal Albatross (*D. epomophora*), and a black patch at the tip; and finally, the breeding cycle of *D. amsterdamensis* starts 2 months later than in populations of *D. exulans*.

The family Diomedea has been thought to comprise 13 species. Ernst Mayr (personal communication) believes the albatros on Amsterdam Island is an allospecies in the superspecies *D. exulans,* that has adapted to subtropical conditions.

The total population including nonbreeding adults and immature birds has been estimated at 30–50 individuals, and Amsterdam Island is certainly its only breeding site. Such a tiny and slow-breeding bird population is very susceptible to disturbance, so we would propose that the breeding site (400 ha) be made a conservation area. ☐



The three largest representatives of the family *Diomedea*: the Wandering Albatross (*D. exulans*), the Royal Albatross (*D. epomophora*) and the new species (*D. amsterdamensis*).

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