A note on the mass formula $m = nm_0$

1968 J. Phys. A: Gen. Phys. 1 455

(http://iopscience.iop.org/0022-3689/1/4/304)

J. PHYS. A (PROC. PHYS. SOC.), 1968, SER. 2, VOL. 1. PRINTED IN GREAT BRITAIN

A note on the mass formula $m = nm_0$

J. S. DOWKER
Department of Theoretical Physics, University of Manchester
MS. received 3rd April 1968

Abstract. The existence of a gravitational dual-mass particle is postulated to account for the mass quantization rule $m = nm_0$ in the same way that Dirac's magnetic monopole accounts for the quantization of charge. Some properties of 'dual matter' are mentioned.

1. Introduction

Attempts to fit the masses of all, or almost all, known particles and resonances by a single formula are not numerous. In this paper we wish to draw attention to those formulae of the type

$$m = \sum_{i=1}^{N} n_i m_{0i} + c \tag{1}$$

where the n_i are integers (or half-integers) and the m_{0i} are some 'basic' masses. c is a 'corrective term' which, if the formula is to be significant, must be small if not zero.

The case of $N = 3$ has been discussed by Costa de Beauregard (1959, 1961 a), the three basic masses corresponding to the leptonic, mesonic and baryonic 'content' of the elementary particles. He also (Costa de Beauregard 1961 b) presented a justification of the formula based on a boundary-value argument, following Schrödinger, and the existence of a fundamental length.

Sternheimer (1964, 1965) and Fickinger and Sternheimer (1965) have discussed the cases $N = 1$ and 2. However, they considered only the case of strongly interacting particles. The electron, for example, was not included. Nevertheless, the large number of particles that are accommodated makes the fits impressive.

The simplest case of $N = 1$, i.e.

$$m = nm_0 + c \tag{2}$$

has recently been analysed by Frosch (1967), who comes to the somewhat surprising conclusion that, for stable particles at least, m_0 is three times the electron mass m_e. In fact, if we ask for the 'best' m_0, in a statistical sense, then it is found that this is $m_0 \simeq 2{\cdot}9999 m_e$ with a very high likelihood.

In this paper we wish to present a possible dynamical explanation for a formula like (2).

2. Possible dynamical explanation

In an earlier paper (Dowker and Roche 1967) we have introduced the concept of dual mass and have shown that the existence of a dual-mass pole particle would result in the quantization of mass according to (2), with $c = 0$, at least in the weak-field and non-relativistic limits. This explanation is the analogue of Dirac's (1931) explanation of the quantization of the electric charge. Any deviation from a strict mass quantization rule, i.e. a non-zero c, could be attributed to the above-mentioned approximations.

The recent, still very tentative, experimental detection of magnetic monopoles makes us hopeful of the actual existence of a dual-mass pole too. (In connection with this 'discovery' we note that, if the basic electric charge were three times the electronic one, this would explain the observed strength of coupling of the monopole. We should like to think that the factor of 3 here is the same as that occurring in Frosch's analysis.)

3. Discussion and conclusion

One question which arises is 'how does the electron fit in with our explanation?'. We see two ways. One is to say that, if $m_0 = 3m_e$, then we can put $m = 3nm_e = n'm_e$, where

n' is an integer, possibly 1. (Frosch's search was for m_0 values in the range 1 MeV to 100 MeV.) In this case the basic mass is the electron's, and we obtain for the dual mass M_0 of the basic dual pole the value (Dowker and Roche 1967)

$$M_0 = \frac{\hbar}{4m_e}$$
$$\simeq 1{\cdot}8 \times 10^{-21}\,\mathrm{s} \simeq 4{\cdot}4 \times 10^{18}\,\mathrm{g} \tag{3}$$

(Earth's mass is about 6×10^{27} g).

The other way is to use Schiff's (1966) argument and say that the dual monopole has a size bigger than the electron's, but less than that of three electrons. The electron's mass would now no longer be required to be quantized.

In both of these cases the dual-mass particle would seem to possess some odd properties. For example, if we accept (3), then the interaction between two dual-mass particles, which is described by a Schwarzschild-like metric, has a singularity at $r \simeq 10^{-10}$ cm, which is larger than the particle's radius.† However, since our whole analysis depends on the linear approximation, this conclusion is somewhat dubious. Another peculiar, but again dubious, property of a 'dual world', i.e. a world constructed of dual matter, is that the gravitational force would dominate any electromagnetic force, in contrast with the normal situation. A rough calculation indicates that the gravitational Bohr radius of a dual atom is about 10^{-100} cm. This fantastically small value suggests that either dual matter does not bind or the analysis is meaningless.‡ Nevertheless, in view of the very high densities which seem to be involved we feel that a more detailed and rigorous investigation of the properties of dual matter might have interesting consequences.

References

Costa de Beauregard, O., 1959, *C.R. Acad. Sci., Paris*, **248**, 932–4.
—— 1961 a, *C.R. Acad. Sci., Paris*, **252**, 849–51.
—— 1961 b, *C.R. Acad. Sci., Paris*, **252**, 1276–8.
Dirac, P. A. M., 1931, *Proc. R. Soc.* A, **133**, 60–72.
Dowker, J. S., and Roche, J. A., 1967, *Proc. Phys. Soc.*, **92**, 1–8.
Fickinger, W. J., and Sternheimer, R. M., 1965, *Phys. Rev.*, **139**, B1021–2.
Frosch, R. F., 1967, *Nuovo Cim.* A, **42**, 677–83.
Schiff, L. I., 1966, *Phys. Rev. Lett.*, **17**, 714–6.
Sternheimer, R. M., 1964, *Phys. Rev.*, **136**, B1364–81.
—— 1965, *Phys Rev.*, **138**, B466–78.

† If the particles are charged there is no singularity.

‡ There might, of course, be bound states with radii of a more reasonable value (say 10^{-8} cm). These would be quantum states of very high quantum numbers and would correspond to a classical limit. They would be analogous to our planetary orbits.