

Particle Mass-Formulae

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Abstract

Important relations among some particle masses are investigated. The eta-prime / eta masses' ratio is noted to be a fraction of integers with high precision. The masses of muon, kaon, eta, and neutron are observed to fit a linear mass formula within an accuracy of 0.25 MeV.

1. Introduction

Many studies can be found in the literature on calculations of the particle mass spectrum. The complexity of advanced parton models and QCD (PDG 2002, [1]) tries to address the fine structure of particle constituents and their interactions, whereas earlier mathematical studies have been dedicated to outlining the gross correlations between the particle masses of isospin multiplets (Nambu, [2]), (Jensen, [3]), (MacGregor, [4]). The present work focuses on relations between particle masses that are satisfied at a level of precision higher than what should be expected from current theory.

2. Relation η' η

Interesting mathematical relations link the mass values of some elementary particles. One example is given by the formula relating the eta and eta-prime mass values:

$$\eta' / \eta = 7 / 4 \quad . \quad [f.1]$$

In fact the ratio of the eta-prime and eta mass expectation values [1] is: 1.750009, though the error on each of the two masses individually is 0.14 and 0.12 MeV, respectively.

3. Mass Formula

Similarly, it is observed that mass differences of particles belonging to different families, charge, and strangeness, are related together with very high precision (preserving spin balance):

$$n - K^0 = \eta - \mu \quad . \quad [f.2]$$

Actually, the experimental mass expectation values [1] of neutron, kaon, eta, and muon, satisfy the equation above within: 0.25 MeV.

This is a residual of the same order of magnitude as the quoted error on the eta mass (two sigmas), and it is about one order of magnitude more precise than Gell-Mann-Okubo's mass formula [1].

4. Previous Work

Various authors [2], [3], [4] have proposed that particle masses are strongly correlated by a mass unit of about 35 MeV, derived from the ratio of pion and muon masses. Their classification leads to the assignment of, in particular, the following integer numbers to the following particles:

$$\mu = 3 ; \pi = 4 ; K = 14 ; \eta = 16 ; \eta' = 28 ; n = 27.$$

With these assignments the formulae f.1 and f.2 become identities. These kinds of models are obviously simplistic (e.g. they do not address mass splitting within isospin multiplets...). However, the explanation of the linear and shell-like regularities of particle masses, as outlined in (Palazzi, [5]), is a challenge to be met by any sophisticated particle model.

5. Summary

The eta / eta-prime mass ratio is consistent with a fraction of integer numbers. A relation is found between the masses of muon, kaon, eta, and neutron (particles with different charge, strangeness and family), respecting spin balance. These relations show correlations and linear functional dependence between the masses of some particles. These results indicate that, independently from the particle models for constituents and their interactions, the mass energy of particles seems to exhibit structural patterns. Future research should be performed along the lines traced in [5].

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