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ヒュッケル近似と素粒子の質量・・・化学と高エネルギー物理の狭間

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The Hueckel approximation and masses of elementary particles….. Researches between chemistry and high energy physics

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1. Introduction

The so called standard model of high energy physics is well accepted by researchers of all of the world. However it contains too many parameters and can not explain the masses of 3 generations of nutrinos, electrons(charged leptons) , d-quarks, and u-quarks which are the most fundamental particles in the field.

About one decay ago Koide[1] found very precise empirical mass formula for the charged leptons:

$$m(e)+m(\mu)+m(\tau)=(2/3)\left\{\sqrt{m(e)}+\sqrt{m(\mu)}+\sqrt{m(\tau)}\right\}^2. \qquad \cdots(1)$$

Koide[1] explained eq.(1) on the basis of the standard model but can not show precise mass formula of quarks. Brannen[2] gave eq.(1) by using the following equation assuming $\eta=\sqrt{2}/2$ and $\delta=2/9=0.2222....$.

$$\lambda(n)\equiv\sqrt{m(n)}=\mu\{1+2\eta\cos(\delta+2n\pi/3)\}\equiv\alpha+2\beta\cos(\delta+2n\pi/3) \qquad \cdots(2)$$

, where $n=1,2,3$ are generation quantum numbers.

Brannen[2] also presented the following mass formula for nutrinos:

$$\lambda(n)\equiv\sqrt{m(n)}=(\mu/3^{11})\left\{1+\sqrt{2}\cos(\delta+\pi/12+2n\pi/3)\right\}. \qquad \cdots(3)$$

2. Chemical aspects of the mass formula

We assume the next mass formula for the fundamental elementary particles:

$$\lambda(l,n) \equiv \sqrt{m(l,n)} = \alpha(l) + 2\beta(l)\cos[\delta/\nu(l) + 2n\pi/3], l = 1,2,3,4; n = 1,2,3;$$
$$\nu = 1/2.1, nutrinos; \nu = 1, electrons; \nu = 2, d-quarks; \nu = 3; u-quarks. \quad \cdots(4)$$

, where l stands for quantum numbers which distinguish each sector of the fundamental particles. Eq. (4) can well reproduce central values of masses of quarks in 10% errors[3]. α and β stand for Coulomb and resonance integrals.

Eq. (4) corresponds to a triangle in a graph-theoretical viewpoints . When we stand for the ratios of three resonance integrals of the 3 edges in the meaning of Hueckel theory as $\rho \equiv \beta'/\beta; \rho' \equiv \beta''/\beta$ we have from eq. (4) $\rho^2 + \rho'^2 = 2$, $\cdots$(5). $3 - 4\cos\Delta = \rho\rho'$, $\cdots$(6). Eqs. (5) and (6) give a relation between the ratios of resonance integrals and the angle $\Delta \equiv \delta/\nu$.

We can have also the next equations from eq. (4).

$$\alpha = (\lambda_1 + \lambda_2 + \lambda_3)/3, \ldots(7); \beta^2 = \left\{3(\lambda_1^2 + \lambda_2^2 + \lambda_3^2) - (\lambda_1 + \lambda_2 + \lambda_3)^2\right\}/18, \ldots(8).$$

In the case of 4 particles which belong to the 1st generation we can show the following empirical mass formula:

$$\lambda(k) = \sqrt{m(k)} = \alpha + 2\beta\cos(k\pi/5); k = 1, neutrino;$$
$$k = 2, electron; k = 3, u-quark; k = 4, d-quark, .\alpha = 1.15, \beta = -0.714(Mev^{0.5}) \ldots..(9).$$

When we give the root-masses of neutrino and electron to the above mass formula it can afford the ones of the quarks in good approximations.

The eq. (9) corresponds to a linear graph of 4 vertices and 3 edges.

The further researches for eqs. (4) and (9) will be necessary for understanding physics and chemistry of subquarks or preons which are constituents of leptons and quarks by applying the standard theory like Koide [1] or by assuming, for example, the next equations:

$$\Psi = \sum_{l=1}^{3 or 4} c_l \phi_l, \ldots(10); h\Psi = \lambda\Psi, \ldots(11); \lambda \equiv \sqrt{m} = \langle \Psi h \Psi \rangle / \langle \Psi \Psi \rangle, \ldots(12).$$

, where h is an operator.

[1] Y. Koide, Phys. Rev., D73, 057901(2006).

[2] C. A. Brannen, carl@brannenworks.com(2006).

[3] S. Eidelman et al., Phys. Lett., B592(2004)1.