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ABSTRACT

A composite quark model based on the symmetry group $SU(10)_{flavour} \otimes SU(10)_{colour}$ with the assumption of mass non-degenerate sub-quarks is considered. Magnetic moments of quarks and sub-quarks are obtained from the observed nucleon magnetic moments. Using these quark and sub-quark magnetic moments, a satisfactory agreement for the radiative decays of vector mesons (ρ,ω) is obtained. The ratio of the masses of the sub-quarks constituting the u,d,s quarks are found to be $M_p/M_n = 0.3953$ and $M_p/M_\lambda = 0.596$, indicating a mass hierarchy $M_p < M_n < M_\lambda$ for the sub-quarks.

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Recently, interest has been evinced in favour of the composite quark model motivated by the proliferation of quarks and leptons, by the observed pattern of "generations" of quarks and leptons 1) and by the observed similarity between quarks and leptons 2). The suggestion that quarks may possess a structure was first given by Chanowitz and Drell 3) who interpreted the deviations from the scaling in e^+e^- experiments in terms of structure of hadronic constituents at 10^{-15} cm. This idea has been supported further by West 4) and Colglazier and Rajaraman 5) by their analysis of e^+e^- and electroproduction experiments, respectively. The central theme of their analysis is that since quarks must be bound together to form hadrons, the interaction responsible for the binding should renormalize the fundamental quark vertices and change the conventional quark-electromagnetic vertex $Q\gamma_\mu$ to $Q\left[F_1(q^2)\gamma_\mu + i\sigma_{\mu\nu} q^\nu \frac{K_q}{2M_q} F_2(q^2)\right]$ endowing a small anomalous magnetic moment K_q and size to the quark of charge Q and mass m_q. By fitting with the experimental data, West 4) obtained estimates on K_q and the size for the quark. The idea of endowing quarks with anomalous magnetic moments has been considered in detail by Kamal 6) and his collaborators in their analysis of the radiative decays of the vector mesons. However, they could not explain both the nucleon magnetic moment ratio and vector meson radiative decay widths simultaneously. This will be considered at a later stage in this paper. It is to be noted that recently Geffen and Wilson 7) proposed the idea that the effective magnetic moments of quarks in hadrons should have an anomalous magnetic moment contribution because of the magnetic coupling of the photon to three or more gluons. They showed then an acceptable fit for the radiative decays of ρ and ω mesons is possible if quarks are allowed to have arbitrary magnetic moments $(\mu_s \neq \mu_d \neq -\frac{1}{2}\mu_u)$ and such an effect is a natural consequence of QCD corrections to the decay amplitudes. It is also to be noted that they did not calculate the QCD corrections explicitly, but treated these corrections phenomenologically by assigning effective magnetic moments to quarks.

A gauge field theoretic description of the composite quark model was first proposed by Pati, Salam and Strathdee 8) who treated quarks and leptons on the same footing. Quarks and leptons are then viewed as composites of a set of fundamental entities called PREONS. The motivation here is the gauge unification of forces to be contrasted with the composite models of quarks and leptons by several authors 9) with an emphasis on classification. The dynamics of the pre-quarks, such as their binding force within the quark and their masses are not known. Although the experimental evidence for the pre-quarks seems to be very remote, it is a matter of theoretical interest to examine the consequences of such a scheme. In the absence of experimental data, guided by previous experience in theoretical areas of physics, it is not unnatural to assume that the pre-quarks have a large constituent mass (~10 TeV) so that their motion within the quark can be made non-relativistic. This was the working hypothesis of Phillips 10) in his composite model for the quarks. Phillips, by using SU(6) wave functions for the pre-quarks, claimed an agreement for the ratio of proton to neutron magnetic moments. However the remarkable agreement claimed by him is fortuitous and the error lied in the calculation of μ_p . This was pointed out also by Gluck 11) who after considering the composite models of Harari and Schupe (see Ref.9) remarked that all composite quark models badly encounter the difficuly of explaining the nucleon magnetic moments.

It is the purpose of this paper to indicate that one can reconcile with the composite quark model in explaining the nucleon magnetic moments and also the radiative decays of ρ and ω mesons. This is done by calculating the quark magnetic moments in the composite quark model of Phillips 10) (with necessary modifications) which deviate from their point-like values. Interpreting the deviation as the anomalous magnetic moment of the quark, good agreement for the ρ and ω radiative decays is obtained.

Let us briefly review the Phillips' 10) model and introduce a modification in the masses of the pre-quarks. This is a direct generalization of the Pati-Salam 2) model and is based on the symmetry group $SU(10)_{flavour} \otimes SU(10)_{colour}$ with the tenth colour state of each flavour as a lepton. Then, the model consists of ten leptons and ten fundamental hadrons each in nine colour states, which are called "omegons". The leptons are treated as fundamental particles and quarks are composed of three omegons. The model possesses five generations of quarks and leptons, the three already known and the two new. In this enlarged model, there are twenty fundamental particles, ten omegons and an equal number of leptons. Generalizing to a case of m flavours and n colours, the model has 2m fundamental constituents. Allowing $SU(10)_{colour}$ to be spontaneously broken by Higgs vacuum to leave $U(1) \otimes SU(9)_{colour}$ as an exact local gauge symmetry, the flavour, colour and electric charges are given by

$$Q = Q_{flavour} + Q_{colour} \qquad (1)$$

$$Q_{flavour} = \left[\begin{array}{cccc} \frac{2}{3} & \frac{2}{3} & \cdots\cdots & -1 \\ -\frac{1}{3} & -\frac{1}{3} & \cdots\cdots & -2 \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \end{array}\right] \begin{array}{l} (1) \\ \\ (2) \\ (3) \\ (4) \\ (5) \end{array} ; \quad Q_{colour} = \left[\begin{array}{cccc} -\frac{1}{9} & -\frac{1}{9} & \cdots\cdots & -1 \\ -\frac{1}{9} & -\frac{1}{9} & \cdots\cdots & -1 \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \end{array}\right] \begin{array}{l} (1) \\ \\ (2) \\ (3) \\ (2) \\ (3) \end{array}$$

$$Q = \left[\begin{array}{cccc} \frac{5}{9} & \frac{5}{9} & \cdots\cdots & 0 \\ -\frac{4}{9} & -\frac{4}{9} & \cdots\cdots & -1 \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \\ \hdashline & ,, & & ,, \end{array}\right] \begin{array}{l} (1) \\ \\ (2) \\ (3) \\ (4) \\ (5) \end{array}$$

where the numbers in the parenthesis denote "generation" in the constituents. The leptons have electric charges 0 to -1 and are grouped 5 SU(2) doublets as:

$$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix} \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix} \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix} \begin{pmatrix} \nu_1 \\ \ell_1^- \end{pmatrix} \begin{pmatrix} \nu_2 \\ \ell_2^- \end{pmatrix} . \qquad (2)$$

The omegons with electric charges $(\frac{5}{9}, -\frac{4}{9})$ are mirrored as

$$\begin{pmatrix} p \\ n \end{pmatrix} \begin{pmatrix} c \\ \lambda \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix} \begin{pmatrix} e \\ j \end{pmatrix} \begin{pmatrix} g \\ k \end{pmatrix} . \qquad (3)$$

Each of the fundamental omegons comesin nine colour states in the representation $SU(9)_c$. The colour nonet of a given flavour say p_i (i = 1,9) consists of three triplets $(p_1p_2p_3)$ $(p_4p_5p_6)$ and $(p_7p_8p_9)$, the members of a triplet are then distinguished by a new degree of freedom "colour shade". Coloured quarks are then colour shadeless composite systems of three colour shaded omegons. The quantum numbers assigned to the omegons (ten of them) are (i) flavour charge $Q_f(\frac{2}{3}, -\frac{1}{3}, \frac{2}{3} - \frac{1}{3}, \frac{2}{3}, -\frac{1}{3}, \frac{2}{3}, -\frac{1}{3})$; (ii) third component of isospin I_3 $(\frac{1}{2}, -\frac{1}{2}, 0, 0, 0, 0, 0, 0, 0, 0)$; (iii) baryon number $N(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, \frac{1}{3})$; (iv) strangeness $S(0, 0, -1, 0, 0, 0, 0, 0, 0, 0)$; (v) charm $C(0, 0, 0, 1, 0, 0, 0, 0, 0, 0)$ and (vi) additional quantum numbers T, B, I, E, G, H such that they are 1 in 5th, 6th, 7th, 8th, 9th and 10th position, respectively and 0 everywhere. The Gell-Mann-Nishijima relation reads as:

$$Q_f = I_3 + \frac{1}{2}(N + S + C + T + B + I + E + G + H) \quad . \tag{4}$$

Then p,n,λ omegons form $SU(3)_{\text{flavour}}$ triplet as well as have three sets of colour shades i.e. they are a (3,3) representation of $SU(3)_{\text{flavour}} \otimes SU(3)_{\text{colour-shade}}$. The isodoublet (ppn) and (pnn) and the isoscalar (pnλ) are members of the colour shadeless (8,1) multiplet in $(3,3) \otimes (3,3) \otimes (3,3)$ and have the usual SU(3) quantum numbers of u,d,s quarks, respectively.

The assignments of the other quarks are c(pnc), t(pnt), b(pnb) etc. The model predicts, besides $c\bar{c}$, $b\bar{b}$, $t\bar{t}$ bound states, four more heavy mesons of T type. In order to bind the omegons in quarks, 80 gauge fields made up of three colour shade changing $SU(3)_{cs}$ octets of super-gluons are supposed to be exchanged among omegons, making the gauge group for omegon strong interaction as $SU(9)_c$. Phillips could identify omegons as SU(9) magnetic monopoles and a neutral system of nine monopoles can cluster in three groups of three. Identification of quarks as clusters of three SU(9) monopoles guarantees zero triality for bound states of quarks. Omegons are all mass degenerate. With omegons as SU(9) monopoles, they carry magnetic charge and are confined in quarks. Leptons do not carry magnetic charge and hence are not confined. The idea of magnetic force confining pre-quarks inside the quark was also given recently by Pati 16).

Let us now consider, for the sake of simplicity, p and n omegons carrying isospin $I = \frac{1}{2}$ and $I_3 = \frac{1}{2}, -\frac{1}{2}$. The Higgs field, introduced at the beginning, appropriate for the first generation of omegons can be denoted by ϕ. It is a natural consequence now to group the left-handed p,n omegons in SU(2) because the flavour generic symmetry group is still SU(2) although the full flavour symmetry group is SU(10). Since we are not discussing the weak or electromagnetic interactions of omegons (they occur only at the quark level) we can symmetrically consider left- and right-handed singlets of p and n, denoted by Ω_L and Ω_R. Defining $\phi = i\,\sigma_2\,\phi^*$ and considering the omegon-Higgs coupling as

$$G_p \left[\Omega_L \,\tilde{\phi}\, \Omega_R + \text{h.c.}\right] + G_n \left[\bar{\Omega}_L \,\phi\, \Omega_R + \text{h.c.}\right] \tag{5}$$

p and n omegons can be given different $(G_p \neq G_n)$ masses by the non-vanishing vacuum expectation value of ϕ. The masses can be made large (∼10 TeV) by an appropriate choice of G_p and G_n. This seems to be natural as the leptons in the tenth colour state in first generation (ν_e, e^-) can be coupled analogously to ϕ. As leptons do not have strong interactions and violate parity maximally in weak processes, the asymmetry in the left- and right-handed components of $\begin{pmatrix}\nu_e\\ e^-\end{pmatrix}$ gives mass for electron only. This scheme can be repeated for generation wise. This is also economical since with one vacuum expectation value (considering first generation) e^-, p and n omegons can be given widely different masses by the choice of f_e, G_p and G_n.

Let us now write down the omegon magnetic moment as

$$\mu_{w_i} = \left[\delta \left(\frac{M}{M_{w_i}}\right) \frac{e_{w_i}}{e}\right] \quad , \tag{6}$$

where M is the proton mass, M_{w_i} is the ith $(i = 1,\ldots,10)$ omegon mass, e_{w_i} $(\frac{5}{9}$ or $-\frac{4}{9})$ is the ith omegon charge and δ is a scale parameter. (In Phillips' 10) model, omegon masses are non-degenerate.) The quark and baryon magnetic moments are calculated in terms of δ's as

$$\mu_u = \frac{1}{27}\,(20\delta_p + 4\delta_n); \quad \mu_d = -\frac{1}{27}\,(5\delta_p + 16\delta_n); \quad \mu_s = -\frac{4}{9}\,\delta_\lambda \tag{7}$$

and

$$\mu_P = \frac{1}{81}\,(88\delta_p + 32\delta_n); \quad \mu_N = -\frac{1}{81}\,(40\delta_p + 68\delta_n); \quad \mu_\Lambda = -\frac{4}{9}\,\delta_\lambda \quad , \tag{8}$$

where $\delta_{p,n,\lambda}$ are $\delta\left(\frac{M}{M_{p,n,\lambda}}\right)$ with M_p, M_n, M_λ as p,n,λ omegon masses, respectively. From the experimental values of μ_p, μ_N and μ_Λ, we find

$$\begin{aligned} &\delta_p = 2.3167 \text{ n m}; \quad \delta_n = 0.9159 \text{ n m} \quad \text{and} \quad \delta_\lambda = 1.3811 \text{ n·m} \\ &\mu_u = 1.8516 \text{ n m}; \quad \mu_d = -0.9717 \text{ n m} \quad \text{and} \quad \mu_s = -0.6138 \text{ n·m} \quad . \end{aligned} \tag{9}$$

Now two points are in order: (1) the numerical values of $\delta_{p,n,\lambda}$ provide an estimate on the ratio of omegon masses as: $M_p/M_n = 0.3953$ and $M_p/M_\lambda = 0.596$ indicating $M_p < M_n < M_\lambda$; (2) the quark magnetic moments deviate from their point-like values ($\mu_u = 0.6666$ n m, $\mu_d = -0.3333$ n·m and $\mu_s = -0.3333$ n·m) and are different from the values of Phillips [10]. They give $\mu_u/\mu_d = -1.9$, close to the recent analysis of Geffen and Wilson [7].

Having obtained the numerical values of $\delta_{p,n,\lambda}$ and $\mu_{u,d,s}$, it is necessary to examine whether these explain other observables in a consistent manner. For this purpose we consider the radiative decays of ρ and ω mesons. The latest and most reliable measurement [12] of $\Gamma(\rho \to \pi\gamma)$ gives 67 ± 7 keV and using the Particle Data Group [13] for the branching ratio $B(\omega \to \pi\gamma)$ together with other experiments [14], $\Gamma(\omega \to \pi\gamma) = 789 \pm 92$ keV, as also used by Ohshima [15]. So, the ratio $\Gamma(\omega \to \pi\gamma)/\Gamma(\rho \to \pi\gamma) = 11.75 \pm 0.15$. In terms of $\delta_{p,n,\lambda}$, the expression for R simply turns out to be

$$R = \left[\frac{5}{3}(5\delta_p + 4\delta_n)/(5\delta_p - 4\delta_n)\right]^2 \tag{10}$$

which together with the values in Eq.(9), yields R = 10.3 close to the experimental data. Alternatively, one can calculate the quark magnetic moments from R and compare with Eq.(9). Since Eq.(9) suggests anomalous magnetic moments for quarks, we write down the quark magnetic moment as

$$\mu_q = x_q\left(\frac{e_q}{e} + k_q\right) \text{n·m} \tag{11}$$

with e_q and k_q as charge and anomalous magnetic moments of quarks, respectively, and $x_q = M/M_q$, M_q being the quark mass.

With this definition one can obtain

$$\mu_P/\mu_N = (8x_u + x_d + 12\, x_u\, k_u - 3\, x_d\, k_d)/(-2x_u - 4x_d - 3x_u\, k_u + 12\, x_d\, k_d)$$

$$R = 9\left[(2x_u + x_d + 3x_u\, k_u - 3x_d\, k_d)/(2x_u + x_d + 9x_u\, k_u + 9\, x_d\, k_d)\right] \quad . \tag{12}$$

Eq.(12) becomes identical to that of Kamal [6] for $x_u = x_d$. We can also view k_u and k_d as effective QCD corrections as done by Geffen and Wilson [7] and quark effective magnetic moment is arbitrary. Using the recent data for R [11)-14)] and QCD calculations for $x_u/x_d = m_d/m_u$, we find the acceptable fit for the R values and μ_p/μ_N giving $k_u = -0.3669$ and $k_d = 0.0808$. It is to be noted that k_u and k_d are small and not in the ratio -2 : 1 (SU(3) symmetry expects $k_u : k_d = -2 : 1$). From the above values of k_u and k_d, we easily find $\mu_u/\mu_d = -1.904$ agreeing with Eq.(9) the composite quark model value.

In summary, we wish to state that the composite quark model based on $SU(10)_{\text{flavour}} \otimes SU(10)_{\text{colour}}$ with non-degenerate omegon masses can be reconciled with the nucleon magnetic moments and also consistently with the ρ, ω meson radiative decays.

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REFERENCES

1) H. Harari, Phys. Rep. 42C, 235 (1978).

2) J.C. Pati and Abdus Salam, Phys. Rev. D8, 1240 (1973).

3) M.S. Chanowitz and S. Drell, Phys. Rev. Letters 30, 807 (1973).

4) G.B. West, Phys. Rev. D10, 829 (1974).

5) E.W.Colglazier and R. Rajaraman, Phys. Rev. D10, 334 (1974).

6) A.N. Kamal, Phys. Rev. D18, 3512 (1978);
B.J. Edwards and A.N. Kamal, Phys. Rev. Letters 36, 241 (1976);
Ann. Phys. (N.Y.) 102, 252 (1976); Phys. Rev. D15, 2019 (1977);
Phys. Rev. Letters 43, 551 (1979);
A.N. Kamal and G.L. Kane, Phys. Rev. Letters 43, 551 (1979).

7) D.A. Geffen and W. Wilson, Phys. Rev. Letters 44, 370 (1980).

8) J.C. Pati, Abdus Salam and J. Strathdee, Phys. Letters 59B, 265 (1975).

9) H. Harari, Phys. Letters 86B, 83 (1979);
M.A. Shupe, Phys. Letters 86B, 87 (1979);
H. Terazawa, Y. Chikashige and K. Akama, Phys. Rev. D15, 480 (1977);
Y. Ne'eman, Phys. Letters 82B, 69 (1979);
R. Raito, University of Helsinki, preprint HU-TFT-79-39 (1979).

10) S.M. Phillips, Phys. Letters 84B, 133 (1979).

11) G. Gluck, Phys. Letters 87B, 247 (1979);
See also H.J. Lipkin, Phys. Letters 89B, 358 (1980).

12) D. Berg et al., to appear in Phys. Rev. Letters, as quoted in Ref.15.

13) Review of Particle Properties, Particle Data Group, LBL-100, April 1978.

14) A. Baldin et al., Sov. J. Nucl. Phys. 13, 431 (1971);
D. Benaksas et al., Phys. Letters 42B, 511 (1972);
J. Keyne et al., Phys. Rev. D14, 28 (1976).

15) T. Ohshima, University of Rochester, preprint COO-3065-256.

16) J.C. Pati, Institute of Physics, Bhubaneshwar, India, preprint (1980).

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