# Chapter 12

# Quark Gluon Model In The Evans Unified Field Theory

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## Abstract

The interaction of quarks and gluons inside a given elementary particle is described through the use of two or more simultaneous Evans wave equations and the equivalent minimal prescription. Approximate quark flavor symmetry in the quark gluon standard model is replaced by the mathematically required exact quark flavor symmetry perturbed by quark gluon momentum exchange. Therefore the apparently different observed quark masses are the result of the interaction of a confined quark with a massive gluon field inside an elementary particle or between confined quarks in different elementary particles. Therefore the six quarks initially have the same mass but different flavors in the hypothetical free state (single quark state of the Evans wave equation), but the different interactions of quark and gluon inside a given elementary particle result in the apparently different confined quark masses observed experimentally. These masses are more accurately the average result of different and transient momentum exchanges of massive quark and massive gluon. Quarks have only been observed to date in a confined state, where quark gluon interaction is always present inside an elementary particle or between two elementary particles. This is essentially a multi particle momentum exchange problem between quark and gluon. Many such interactions are possible because there are six quark flavors of $SU(n)$ symmetry and three quark colors of $SU(3)$ symmetry in general, giving rise to many possible permutations and combinations and therefore to many types of elementary particle as observed experimentally. The Evans uni-

fied field theory is rigorously objective (i.e. generally covariant) throughout and in consequence there can be no massless particles, the radiated gluon is therefore massive and not massless as in the standard model. The gluon field has $SU(3)$ symmetry and is also described by an Evans wave equation. The many possible types of interaction between quarks and gluons is therefore always described by simultaneous Evans wave equations defining momentum exchange. These equations must be solved numerically and simultaneously in general with given initial and boundary conditions.

Keywords: Evans unified field theory, quark gluon model, flavor symmetry, color symmetry, gluon potential field.

## 12.1 Introduction

In the standard model of quark gluon interaction [1] there are six quark flavors $u, d, s, c, t$ and $b$ and three quark colors $R, W$, and $B$. The quarks are matter fields. The potential of the radiated gluon field also has $SU(3)$ symmetry [1] and in the standard model the various gluons are considered to be a massless particles. The masses of the six quarks are not the same experimentally: $u$ and $d$ for example have approximately the same mass but the mass of $s$ is very different. In contrast the masses of the left and right electron appearing in the Dirac equation and observed in the Stern Gerlach experiment [2] (the effect of a magnetic field of right design on an electron beam) are exactly the same within contemporary instrumental precision. The right and left electrons are therefore said to be degenerate in the absence of a magnetic field [1]. Therefore they can be described by an exact symmetry, in this case the $SU(2)$ symmetry of the appropriate representation space of the Dirac equation. This $SU(2)$ symmetry implies the use of two Pauli spinors, one right and one left. These are both column two vectors, which when superimposed on each other define the Dirac four spinor, a column vector with four components. The Evans unified field theory [3]– [18] shows that the Dirac equation is a limit of the Evans wave equation defined by:

$$kT = \frac{m^2c^2}{\hbar^2} = \frac{mk}{V}. \tag{12.1}$$

Here $T$ is the scalar energy momentum density defined by the fundamental field equation of relativity theory for all matter and radiated fields:

$$R = -kT \tag{12.2}$$

where $R$ is scalar curvature and $k$ is Einsteins constant. In Eq.(12.1) $m$ is mass, $\hbar$ is the reduced Planck constant and $c$ is the speed of light. Eqs.(12.1) and (12.2) imply that every elementary particle and every quark and radiated particle such as a photon and gluon have a rest volume defined by:

$$V = \frac{\hbar^2 k}{mc^2}. \tag{12.3}$$

The Evans field theory shows that the Dirac spinor is a special relativistic example or limit of the tetrad, the fundamental field of the Palatini variation of general relativity [19]– [21]. The tetrad is the eigenfunction of the Evans lemma:

$$\Box q^a{}_\mu = Rq^a{}_\mu \tag{12.4}$$

which gives the Evans wave equation:

$$(\Box + kT)\, q^a{}_\mu = 0 \tag{12.5}$$

using Eq.(12.2). The Dirac equation is obtained straightforwardly from the Evans wave equation using Eq. (12.1) and a $2 \times 2$ tetrad:

$$q^a{}_\mu = \begin{bmatrix} q^R{}_1 & q^R{}_2 \\ q^L{}_1 & q^L{}_2 \end{bmatrix}. \tag{12.6}$$

Transposition of the two row vectors of the tetrad into two column vectors gives the column four vector which is the Dirac spinor:

$$\psi = \begin{bmatrix} q^R{}_1 \\ q^R{}_2 \\ q^L{}_1 \\ q^L{}_2 \end{bmatrix} = \begin{bmatrix} \xi^R \\ \xi^L \end{bmatrix}. \tag{12.7}$$

The Pauli spinors are therefore identified as:

$$\xi^R = \begin{bmatrix} q^R{}_1 \\ q^R{}_2 \end{bmatrix}, \xi^L = \begin{bmatrix} q^L{}_1 \\ q^L{}_2 \end{bmatrix}. \tag{12.8}$$

Therefore the Dirac equation is a result of differential geometry, because the lemma (12.4) is an identity obtained straightforwardly from the standard tetrad postulate [22] of Cartan's differential geometry:

$$D_\mu q^a{}_\nu = 0 \tag{12.9}$$

where $D_\mu$ denotes the covariant derivative. This result is one of the major advances of Evans field theory because it allows the generally covariant description of momentum exchange between any radiated and matter fields in nature. This result yields an objective (i.e. generally covariant) description of all nature, from quarks to cosmological objects, i.e. of any type of matter fields interacting with any type of radiated field.

In Section 12.2 the approximate quark flavor symmetries of the standard model are replaced by exact quark flavor symmetries perturbed by quark gluon momentum exchange processes (of which very many are possible giving rise to many observed elementary particles [1]). The interacting quark field and gluon field are described by two or more simultaneous Evans wave equations which must be solved numerically and simultaneously with given initial and boundary conditions. In Section 12.3 consideration is extended to include the quark colors, for each flavor there are three colors.

## 12.2 Perturbation Of Exact Flavor Symmetry By Momentum Exchange

In the standard model the use is made of approximate flavor symmetries. The simplest is $SU(2)$, in which the Dirac type spinor is [1]:

$$\xi = \begin{bmatrix} u \\ d \end{bmatrix}. \tag{12.10}$$

This is approximate because u and d do not have the same masses and are therefore only approximately degenerate in the absence of a perturbing field. In contrast the right and left electrons of the original Dirac equation are exactly degenerate in the absence of a magnetic field as discussed already. This is a severe conceptual problem for the standard model because in group theory and in nature there can only be exact symmetries, no approximate symmetries. The three quark model has $SU(3)$ symmetry, the four quark model has $SU(4)$ symmetry and so on up to the $SU(6)$ symmetry of the six quark model. These symmetries are group symmetries and again cannot be approximate. In the three quark model the Dirac type spinor is a three spinor:

$$\xi = \begin{bmatrix} u \\ d \\ s \end{bmatrix}. \tag{12.11}$$

and so on up to the six spinor of the six quark model. The problem of approximate symmetry becomes worse and worse because the six quark masses are not even approximately the same experimentally. In the Evans unifed field theory each spinor is governed by the wave equation, for example:

$$(\Box + kT) \begin{bmatrix} u \\ d \end{bmatrix} = 0 \tag{12.12}$$

for the two quark model, and

$$(\Box + kT) \begin{bmatrix} u \\ d \\ s \end{bmatrix} = 0 \tag{12.13}$$

for the three quark model and so on up to the six quark model:

$$(\Box + kT) \begin{bmatrix} u \\ d \\ s \\ c \\ t \\ b \end{bmatrix} = 0. \tag{12.14}$$

Thus, in the Evans unified field theory, there is gravitational interaction between quarks inside an elementary particle, or between quarks in two different elementary particles. This occurs in addition to the interaction between quarks mediated by gluons. Similarly, there is gravitational interaction between electrons in the Evans unified field theory in addition to the interaction mediated by photons. In the presence of gravitational interaction:

$$kT \neq \frac{m^2c^2}{\hbar^2}. \tag{12.15}$$

In the absence of gravitational interaction Eq.(12.1) applies. The problem at hand is therefore simplified if we neglect gravitational interaction to one of interaction between quarks and gluons. In the standard model the $SU(3)$ quark color symmetry (Section 12.3) is considered to be exact, and the quark color spinor is [1]:

$$\psi = \begin{bmatrix} R \\ W \\ B \end{bmatrix}. \tag{12.16}$$

This three spinor plays a role analogous to right and left spin in the Pauli spinors of the right and left electrons, and is introduced following considerations [1] similar to the Pauli exclusion principle for electrons. The gluon field in the standard model is the radiated field of $SU(3)$ symmetry that mediates the strong nuclear interaction. The gauge potential ${A^a}_\mu$ of the gluon field has eight components. In the Evans field theory each component of ${A^a}_\mu$ obeys the Evans wave equation:

$$(\Box + kT)\,{A^a}_\mu = 0. \tag{12.17}$$

Therefore the interaction of a gluon with a quark is described by a momentum exchange process in the Evans field theory, in which each type of gluon has mass as described by Eq.(12.17). In the special relativistic limit (12.1), Eq.(12.17) reduces to:

$$\left(\Box + \frac{m_g^2c^2}{\hbar^2}\right){A^a}_\mu = 0 \tag{12.18}$$

where $m_g$ is the mass of a given gluon. In the standard model there is no gluon mass, and no photon mass, in contradiction to the observation of photon mass in the Eddington and NASA Cassini experiments, precise to one part in one hundred thousand. The absence of photon and gluon mass from the standard model is therefore another major conceptual problem for that model.

The free quark flavors in the absence of gravitational interaction are described by:

$$\left(\Box + \frac{m_q^2c^2}{\hbar^2}\right)\psi = 0 \tag{12.19}$$

and the free gluons in the absence of gravitational interaction by:

$$\left(\Box + \frac{m_g^2c^2}{\hbar^2}\right)A = 0. \tag{12.20}$$

In Eq.(12.19) an exact symmetry is used in the Evans field theory, as required by basic group theory and in contrast to the meaningless approximate symmetries of the standard model. In other words the six quarks flavors have the same mass in the free state.

Eqs.(12.19) and (12.20) can be factorized [3]– [18] into first order differential equations:

$$(i\gamma^a \partial_a - m_q c/\hbar)\, \psi = 0 \tag{12.21}$$

$$(i\gamma^a \partial_a - m_g c/\hbar)\, A = 0 \tag{12.22}$$

where $\gamma^a$ is the Dirac matrix.

The momentum exchange between any type of quark and any type of gluon is given through a minimal prescription as follows:

$$(i\hbar\gamma^a \left(\partial_a - igA_a\right) - m_q c)\, \psi = 0 \tag{12.23}$$

$$(i\hbar\gamma^a \left(\partial_a + igA_a\right) - m_g c)\, A = 0. \tag{12.24}$$

Here g is a coupling parameter analogous to the e used in describing momentum exchange between photon and electron in quantum electrodynamics in the Evans field theory [3]– [18]. Thus Eqs.(12.23) and (12.24) describe quantum chromodynamics in the Evans unified field theory in the absence of any consideration of gravitational interaction. There are six quark flavors, three quark colors and eight types of gluon in general, so there is a total of $6 \times 3 \times 8 = 144$ different coupling parameters $g$ in general. The effective mass generated in each type of interaction is defined by [3]– [18]:

$$kT = \left(\frac{m_q c}{\hbar}\right)^2_{eff} = \left(\frac{m_q c}{\hbar}\right)^2 + \frac{g m_q c}{\hbar^2}\gamma^a \left(A_a + A_a^*\right) + \frac{g^2}{\hbar^2} A_a^* A^a. \tag{12.25}$$

The experimental observation of apparently different confined quark masses is therefore explained generically by Eq.(12.25), the apparently different confined quark masses of the standard model being in Evans field theory a well defined combination of free quark and free gluon mass and appropriate coupling parameter $g$. In various elementary particles there are different quark combinations [1]. Baryons are bound states of three quarks, and mesons are quark anti-quark states. Baryons participate in the strong interactions and have overall half integral spins and so interaction between baryons is mediated by gluons according to Eqs.(12.23) and (12.24). In the standard model basic concepts such as the degeneracy of multiplets of hadrons are based on the approximate quark degeneracy. Hadrons participate in the strong interaction and so the interaction between hadrons takes place through gluon exchange. A given representation of $SU(3)$ for example contains several representations of $SU(2)$ [1], and from this it is concluded in the standard model that an $SU(3)$ supermultiplet contains several isospin multiplets of different strangeness $S$. This group theoretical reasoning is the basis of for example the Gell-Mann Nishijima relation used in the GWS theory of the standard model. However, the fundamental but approximate quark flavor degeneracy, as we have argued, is meaningless, bringing into question all of these basic concepts of the standard model. In the Evans field theory an exact quark flavor degeneracy is used, and this is self consistent, as well as objective, physics.

## 12.3 Quark Color Symmetry

The quark color symmetry of $R, W$ and $B$ was introduced to address the problem posed by Fermi Dirac statistics [1]. In contrast to the flavor symmetry the color symmetry is exact. The relevant spinor is:

$$\psi = \begin{bmatrix} u^R \\ u^W \\ u^B \end{bmatrix} etc. \tag{12.26}$$

and has $SU(3)$ symmetry. Therefore for each quark flavor there are three colors. The standard model therefore uses a mixture of approximate and exact symmetries for flavor and color wavefunctions. In the Evans field theory in contrast, exact group theoretical symmetries are used throughout, the theory is generally covariant throughout, and the basic contradictions between quantum mechanics and general relativity are removed through the use of massive photons and gluons and a geometrically based approach to the whole of physics.

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