Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

Global Journal

of Science Frontier Research: A

Physics and Space Science

A Flaw in Hubble Law

Critical Analysis of the Coefficient α

Highlights

Colored Gluon in Standard Model

Analytical Solution of Bessel Integrals

Discovering Thoughts, Inventing Future

VOLUME 23 ISSUE 2 VERSION 1.0

Global Journal of Science Frontier Research: A
Physics & Space Science

Volume 23 Issue 2 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
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Employer Identification Number (EIN):
USA Tax ID: 98-0673427

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945th Concord Streets,
Framingham Massachusetts Pin: 01701,
United States of America
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Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
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Packaging & Continental Dispatching

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Pricing (Excluding Air Parcel Charges):

Yearly Subscription (Personal & Institutional)
250 USD (B/W) & 350 USD (Color)

Contents of the Issue

Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Critical Analysis of the Coriolis Coefficient α

By Oscarjm Jimenez Medina

Abstract- The main objective of this research work, is to make a critical analysis of the application, of coefficient α, since it was proposed by Coriolis in 1836. According to the international literature and the internet, widely consulted by the author of this work, the Coriolis coefficient for the correction of the velocity head (kinetic energy), is affirmed and recognized in the conduction fluid flows, because when considering the average velocity (ratio between discharge and velocity), as the average of the actual distribution of velocities occurring in the cross section, an error occurs, due to the non-uniform distribution of velocities. The author of this technical article, in performing a thorough and detailed analysis of the deduction of the coefficient α, the continuity equations, Bernoulli (laws of conservation of mass and energy, respectively, applied to the flow of fluids), as well as the general formulas of fluid resistance, Weisbach-Darcy, etc. has come to the conclusion that while the coefficient of Coriolis actually exists, the way in which it has been used is not the right one.

Keywords: coriolis coefficient α*, continuity equation.*

GJSFR-A Classification: DDC Code: 346.730467905 LCC Code: K5

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Strictly as per the compliance and regulations of:

Critical Analysis of the Coriolis Coefficient α

Análisis crítico del coeficiente α de Coriolis

Oscarjm Jimenez Medina

Resumen- El objetivo principal de este artículo técnico es hacer un análisis crítico de la aplicación del coeficiente α, desde que fue propuesto por Coriolis en 1836. De acuerdo con la bibliografía internacional, ampliamente consultada por el autor de este trabajo, se afirma y reconoce al coeficiente α de Coriolis para la corrección de la carga de velocidad (energía cinética), en las conducciones de fluidos, porque al considerar la velocidad, como la media de la distribución real de velocidades de la sección, se produce un error, producto a la distribución no uniforme de velocidades. Lo expuesto en el presente trabajo tiene como premisa, el empleo del método teórico-deductivo, la realización de un consciente y minucioso estudio de la deducción del coeficiente α, así como la aplicación de las leyes de conservación de la masa y de la energía (ecuaciones de continuidad y de Bernoulli), respectivamente, aplicadas al flujo de fluidos), así como la fórmula general de la resistencia fluida, de Weisbach-Darcy, del régimen crítico, etcétera. De acuerdo con los resultados obtenidos en los ejemplos 1. "Tubería de diámetro variable" y 2. "Canal rectangular", así como el análisis de la ecuación de energía, por medio de la cual, se obtiene lo aquí propuesto, se ha llegado a la conclusión, de que si bien el coeficiente α, de Coriolis existe realmente, la forma en que se ha empleado no es la correcta.

Palabras clave: coeficiente de coriolis α, ecuación de continuidad.

Abstract- The main objective of this research work, is to make a critical analysis of the application, of coefficient **α**, since it was proposed by Coriolis in 1836. According to the international literature and the internet, widely consulted by the author of this work, the Coriolis coefficient for the correction of the velocity head (kinetic energy), is affirmed and recognized in the conduction fluid flows, because when considering the average velocity (ratio between discharge and velocity), as the average of the actual distribution of velocities occurring in the cross section, an error occurs, due to the non-uniform distribution of velocities. The author of this technical article, in performing a thorough and detailed analysis of the deduction of the coefficient α, the continuity equations, Bernoulli (laws of conservation of mass and energy, respectively, applied to the flow of fluids), as well as the general formulas of fluid resistance, Weisbach-Darcy, etc. has come to the conclusion that while the coefficient of Coriolis actually exists, the way in which it has been used is not the right one.

Keywords: coriolis coefficient α, continuity equation.

I. Introducción

El objetivo principal de este trabajo es realizar un análisis crítico y detallado, del coeficiente α de Coriolis (Chow, 1959; León, 2000;Rocha, 2007; Sotelo, 2002). Primeramente no se tienen antecedentes con relación a lo propuesto por Gaspar Coriolis en 1836, lo que se puede especular es que fue utilizado por Osborne Reynolds en 1883 en su experimento para caracterizar los flujos laminar y turbulento ($Re < 2000$ y$Re > 4000$), respectivamente. Es necesario aclarar que esto es solo una intuición del que suscribe, por la relación que se observa entre ambos trabajos. Lo aquí propuesto persigue la correcta aplicación del coeficiente α de Coriolis, de acuerdo a la investigación presentada. Después de demostrarlo con los resultados de los ejemplos y la aplicación de la ley de conservación de la energía, se llega a la conclusión que el coeficiente α, no es para corregir el error que se produce, al considerar la velocidad, como la media de la distribución real de velocidades que ocurren en la sección hidráulica (León, 2000; Nekrasov, 1968), si no para evaluarla. El autor afirma que sería muy saludable aplicar correctamente el coeficiente de Coriolis α, de lo contrario se continuará cometiendo un error de concepto, lo que conlleva a resultados sin fundamentos en el cálculo de la carga de velocidad y por consiguiente en todo en lo que ella participa, p. ej., ecuaciones, de Bernoulli, de Weisbach-Darcy (Agroskin, 1960; Montes, 2000), ley general de la resistencia fluida, etc. Esta propuesta persigue, la obtención de resultados lo más veraces y precisos posibles del fenómeno estudiado, analizados de forma sencilla y rápida en la solución de este problema.

II. Metodología

Se utiliza el método analítico-deductivo. Haciendo una descripción y examen crítico de la deducción del coeficiente α de Coriolis, así como la aplicación de las leyes de conservación de la masa, de la energía y de la resistencia fluida, utilizando la lógica y las matemáticas para dar respuesta al problema planteado. Y es el fundamento que utiliza el autor para demostrar la veracidad de lo propuesto en este artículo.

III. Planteamiento

Deducción del coeficiente de Coriolis α (León, 2000).

Si se considera E_c como la energía del agua (peso de la masa de
Agua * carga a velocidad), entonces:

$$dE_C = \gamma * dQ * \frac{V_m^2}{2g} = \gamma * \mathrm{d}A * \frac{V_m^2}{2g} \quad (1)$$

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O lo que es lo mismo:

$$dE_C = \gamma * V_m^3 * dA \qquad (2)$$

Y la energía cinética total será:

$$E_C = \frac{\gamma}{2g} * V_m^3 * dA \qquad (3)$$

También puede escribirse que:

$$E_C = \gamma * Q * h_V = \gamma * V * A * h_V \qquad (4)$$

Entonces igualando las expresiones anteriores se tiene:

$$h_V = \frac{\int V^3 * dA}{2g * V_m * A} = \frac{\int V^3 * dA}{V_m^3 * A}\left(\frac{V_m^2}{2g}\right) \qquad (5)$$

O sea:

$$h_V = \propto * \frac{V_m^2}{2g} \qquad (6)$$

Y de ahí que la ecuación de cálculo de αsea:

$$\propto = \frac{\int V^3 * dA}{V_m^3 * A} \qquad (7)$$

Que expresada en incrementos finitos, se convierte en la ecuación De trabajo:

$$\propto = \frac{\sum_{i=1}^{n} V_{i*\Delta A}^3}{V_m^3 * A} \qquad (8)$$

Donde *n* representa el número total de puntos en que se discretizó la sección transversal.

Esta es la deducción del coeficiente α de Coriolis (León, 2000).

Pero no por insistir se incurre en repetición innecesaria. El que suscribe recalca que, la ecuación de Bernoulli (Ecuación fundamental de la hidrodinámica), fue propuesta, casi un siglo (98 años), antes que el coeficiente de Coriolis α.

¿Cómo se aplicóentonces Bernoulli, antes de la propuesta de Coriolis)?

IV. Información

Algunas fórmulas para evaluar a α, en la aplicación de los problemas prácticos de hidráulica (Chow, 1959; León, 2000; Sturm, 2001;Jiménez; 2015):

$$\propto = 1 + 3\mu^2 - 2\mu^3 \qquad (9)$$

$$\mu = 2.5 * \frac{V_*}{V} = \frac{V_{max}}{V} - 1 \qquad (10)$$

$$\propto = 1 + 2.34375 * f_{W-D} - 1.3818 * f_{W-D}^{\frac{3}{2}} \qquad (11)$$

$$\propto = 1 + 9.375 * C_R - 11.0488 * C_R^{\frac{3}{2}} \qquad (12)$$

$$\propto = 1 + \frac{183.9375}{C_{CH}^2} - \frac{960.1347}{C_{CH}^3} \qquad (13)$$

$$\alpha = 1 + 183.9375 * \frac{n_M^2}{R_h^{\frac{1}{3}}} - 960.1347 * \frac{n_M^3}{R_h^{\frac{1}{2}}} \qquad (14)$$

El coeficiente de fricción $f_{W-D,}$ de Weisbach-Darcy, fue validado por el investigador Indio, Jain Swamee, en 1980.(White, 2008).

Lo planteado para el coeficiente de Coriolis α (1836), es igualmente aplicable al coeficiente de Boussinesq β (1877): (Chow, 1959; Jiménez, 2015).

$$\beta = 1 + \mu^2 \qquad (15)$$

$$\mu = 0.883883 * f_{W-D}^{\frac{1}{2}} \qquad (16)$$

$$\mu = 1.767767 * C_R^{\frac{1}{2}} \qquad (17)$$

$$\beta = 1 + 0.78125 * f_{W-D} \qquad (18)$$

$$\beta = 1 + 3.12500 * C_R \qquad (19)$$

$$\beta = 1 + \frac{61.31250}{C_{CH}^2} \qquad (20)$$

$$\beta = 1 + 61.1250 * \frac{n_M^2}{R_h^{\frac{1}{3}}} \qquad (21)$$

Las fórmulas para los coeficientes α y β de Coriolis y de Boussinesq, respectivamente, que se exponen aquí son las correctas, y no las que están en la bibliografía (Rocha, 2007; pág.130; Sotelo, 2002: pág.335):

$$\alpha = 1 + 1.94 * f_{W-D} - 1.55 * f_{W-D}^{\frac{3}{2}} \qquad (22)$$

$$\beta = 1 + 0.94 * f_{W-D}$$

V. Fundamentos

Ecuación de continuidad

$$Q = V * A \qquad (24)$$

Ecuación de Bernoulli

$$Z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + hf_{1-2} \qquad (25)$$

$$hf = C_R * \frac{L}{R_h} * \frac{V^2}{2g} = f_{W-D} * \frac{L}{D_i} * \frac{V^2}{2g} = 4C_R * \frac{L}{4R} * \frac{V^2}{2g} \qquad (26)$$

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Para los regímenes de flujo permanente e impermanente, así como para el laminar o turbulento, el flujo debe satisfacer la ecuación de continuidad.

Se debe recordar que las ecuaciones de continuidad y Bernoulli, son las leyes de conservación de la masa y de la energía, aplicadas al flujo de fluidos, respectivamente.

Ley: es una regla o norma. Se trata de un factor constante o invariable de las cosas, que nace de una causa primera.

Son las relaciones existentes entre los elementos que intervienen en un fenómeno.

a) Número de Froude

El número de Fraudé es un número adimensional que relaciona el efecto de las fuerzas de inercia y las fuerzas de gravedad que actúan sobre un fluido:

$$F_R = \frac{V}{\sqrt{g*D}} \qquad (27)$$

$F_R = 1$: régimen crítico.

$F_R < 1$: régimen sub- crítico.

$F_R > 1$: régimen súper – crítico.

b) Número de Reynolds

El número de Reynolds es un número adimensional que relaciona el efecto de las fuerzas de inercia y las fuerzas de viscosidad que caracterizan un fluido, en laminar o turbulento.

$$R_e = \frac{V*D}{\nu} = \frac{4V*R_h}{\nu} \qquad (28)$$

$R_e \leq 2000$: Flujo laminar, $\alpha = 2$, constante.

$R_e \geq 4000$: Flujo turbulento, $\alpha = 2$ **,** variable.

VI. Resultados y Discusión

Lo primero y más importante que fundamenta esta propuesta es la ecuación de continuidad (principio de conservación de la masa):

$$Q = V * A \qquad (29)$$

Esta ecuación es válida para cualquier valor de **α**.

Régimen uniforme. Distribución uniforme de velocidades:

($\alpha = 1$, cte. Para cualquier valor de *Re*). Supuesto.

Régimen turbulento. Distribución logarítmica de velocidades.

($\alpha > 1$, variable y $Re > 4000$).

Régimen laminar. Distribución parabólica de velocidades:

($\alpha = 2$, Cte. y $Re < 2000$).

Entonces no cabe duda que el coeficiente **α** de Coriolis está implícito en el parámetro velocidad de la ecuación de continuidad, así como en las otras ecuaciones aquí expuestas, porque ella tiene el mismo significado físico en todas ($V = Q/A$).

Con relación a la ecuación de Bernoulli, además de que en ella

($V = Q/A$), ésta fue propuesta casi un siglo antes que **α**, de Coriolis, 1738 *vs.* 1836, respectivamente. Cuando Coriolis nació, en 1892, ya Bernoulli hacia 10 años que había fallecido. ¿Por qué y cuándo se introdujo ∝ en la ecuación Bernoulli?

VII. Cálculos

A continuación se realizan dos ejemplos de cálculo, donde se utilizan dos figuras representativas, Figura 1 y Figura 2, respectivamente. Con los resultados obtenidos en ellos se confirma el objetivo del trabajo presentado.

Ejemplo 1. Tubería telescópica

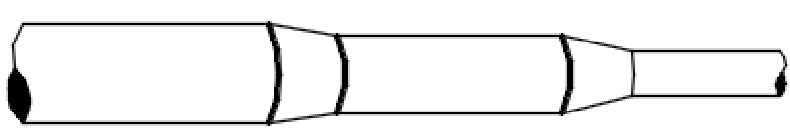

Figura 1: Tubería telescópica (diámetro variable), diámetros, 0.1 m, 0.05 m y 0.01 m, de izquierda a derecha.

Datos:

$Q = 0.000157$ m³/s; $Ks = 0.0005$ m; $g = 9.81$ m/s²; $\nu = 1 * 10^{-6}$ m²/s.

$D_1 = 0.1$ m; $A_1 = 0.00785$ m²; $V_{mr1} = 0.02$ m/s; $Re_1 = 2\,000$;

$f_{W\text{-}D1} = 0.032$; $C_{R1} = 0.008$; $\alpha_1 = 2.0$; $V_{m1} = 0.01414$ m/s;

$Q_1 = V_{mr1} * A_1 = 0.000157$ m³/s; $Q_1 = (\alpha_1)^{1/2} * V_{m1} * A_1 = 0.000157$ m³/s.

$h_{v1} = V_{mr1}^2/2g = 0.00002$ m.

Según la bibliografía, $h_{v\alpha 1}= \alpha_1 * V_{mr1}^2/2g= 0.0004$ m, es dos veces la calculada.(Chow, 1959; León, 2000).

$D_2 = 0.05$ m;$A_2 = 0.00196$ m^2;$V_{mr2} = 0.08$ m/s;$Re_2 = 4\,000$;

$f_{W\text{-}D2} = 0.0506$;$C_{R2} = 0.01265$;$\alpha_2 = 1.1028$;$V_{m2} = 0.0762$ m/s;

$Q_2 = V_{mr2} * A_2 = 0.000157$ m^3/s; $Q_2 = (\alpha_2)^{1/2} * V_{m2} * A_2 = 0.000157$ m^3/s; $h_{v2} = V_{mr2}^2/2g = 0.00033$ m.

Según la bibliografía, $h_{v\alpha 2} = \alpha_2 * V_2^2/2g = 0.00036$ m es 1.1028 veces la calculada. (Chow, 1959; León, 2000).

$D_3= 0.01$ m;$A_3= 0.0000785$ m^2;$V_{mr3}= 2.0$ m/s;$Re_3= 20\,000$;

$f_{W\text{-}D3}= 0.0734$;$C_{R3}= 0.01835$;$\alpha_3= 1.1445$;$V_{m3}= 1.869$ m/s;

$Q_3= V_{mr3} * A_3= 0.000157$ m^3/s;$Q_3= (\alpha_3)^{1/2} * V_{m3} * A_3= 0.000157$ m^3/s.

$h_{v3}= V_3^2/2g = 0.20387$ m.

Según la bibliografía, $h_{v\alpha 3} = \alpha_3 * V^2/2g = 0.23333$ m, es 1.1445 veces la calculada. (Chow, 1959; León, 2000).

$Q_1= V_{mr1} * A_1= 0.000157 = Q_2= V_{mr2} * A_2= 0.000157 = Q_3= V_{mr3} * A_3= 0.000157$ m^3/s.

$Q_1= \alpha_1^{1/2} * V_{m1} * A_1= Q_2= \alpha_2^{1/2} * V_{m2} * A_2= Q_3= \alpha_3^{1/2} * V_{m3} * A_3= 0.000157$ m^3/s.

Observar que para $\alpha_1= 2$, $\alpha_2= 1.103$, $\alpha_3= 1.145$, se cumple la ecuación de continuidad $Q = V * A$. Entonces es indiscutible que el coeficiente α, de Coriolis está incluido en el parámetro velocidad de la referida ecuación, de lo que se infiere que es un error de concepto corregir la velocidad aplicándole el coeficiente α.

Ejemplo 2. Canal de sección rectangular

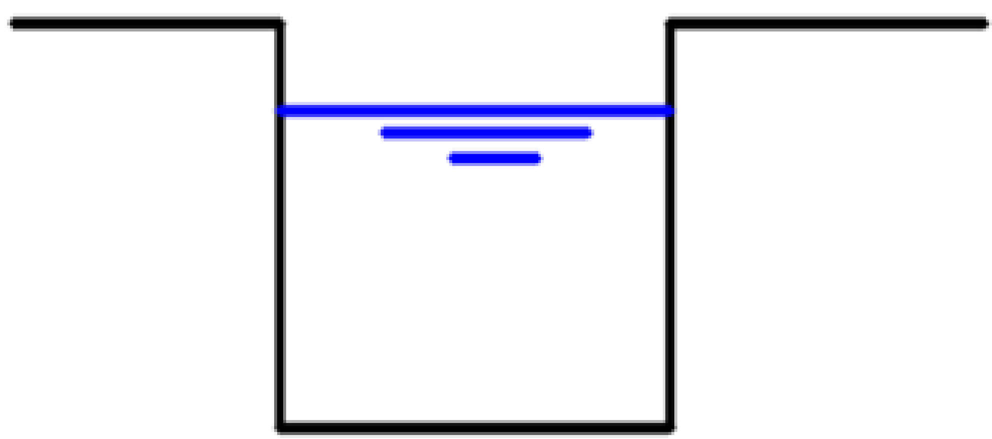

Figura 2: Canal de sección rectangular de $b = 0.40$ my revestido de cemento estucado.

Datos: $Q = 0.0297$ m^3/s;$b = 0.40$ m; $Ks = 0.00025$ m; $g = 9.81$ m/s^2;$\nu = 1 * 10^6$m^2/s (para el agua a 20 ^{0}C); S = 0.00215.

a) *Ecuación del régimen uniforme (Jiménez, 2015)*

$$\frac{C_R^{\frac{1}{2}} * Q}{(2g * R_h * S)^{\frac{1}{2}}} = A * R^{\frac{1}{2}} \qquad (29)$$

$$C_{CH} = \sqrt{\frac{2g}{C_R}} \qquad (30)$$

$$n_M = \sqrt{\frac{C_R}{2g}} * R_h^{\frac{1}{6}} \qquad (31)$$

Cálculo por tanteo y error en Excel ($h_N= 0.101$m):

$A_N= 0.0404$ m^2;$V_N= 0.735$ m/s;$Re_N= 196\,020$; $C_R= 0.00522$;

$f_{W\text{-}D}= 0.021$;$\alpha_N= 1.045$;$V_{mN}= 0.719$ m/s; $R = 0.0671$ m; $Q_N= V_N * A_N= 0.0297$ m^3/s; $Q = (\alpha)^{½} * V_m * A = 0.0297$ m^3/s.

$$V_N = \frac{Q_N}{A_N} = 0.735 \ {}^{m}/_{s} \qquad (24)$$

$$V_N = \sqrt{\frac{2g}{C_R} * R_h * S} = 0.735 \ {}^{m}/_{s} \qquad (32)$$

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b) *Ecuación base del régimen crítico. (King, 1959)*

$$\frac{Q^2}{g} = \frac{A^3}{T} \quad (33)$$

$$T = \frac{D}{A} \quad (34)$$

$$Q = \sqrt{g*D}*A \quad (35)$$

$$Q = V*A \quad (24)$$

$$V = \sqrt{g*D} \quad (36)$$

Cuando ocurre la profundidad crítica, la Ecuación (33) se verifica para cualquiera que sea la forma geométrica de la sección, lo que significa que $h_C \rightarrow A_C \rightarrow P_C \rightarrow R_C \rightarrow V_C \rightarrow Q_C \rightarrow S_C$ son valores únicos de la sección en cuestión, así como los parámetros hidráulicos.

c) *Profundidad crítica para la sección rectangular*

$$h_c = \left(\frac{Q}{b*\sqrt{g}}\right)^{\frac{2}{3}} = 0.0825\,m \quad (37)$$

$$h_C = 0.8252\,m$$

A_C= 0.033 m^2, V_C= 0.90 m/s; Re_C = 210 240; C_{RC} = 0.00535; $f_{W\text{-}DC}$ = 0.0214; α_C = 1.0458;V_{mC} = 0.88 m/s; R_C = 0.0584 m.

$$Q_C = V_C * A_C = 0.0297\ m^3/s$$

Q_C = 0.0297 m^3/s

$$Q_C = \sqrt{\propto}*V_{mC}*A_C = 0.0297\ m^3/s$$

Q_C= 0.0297 m^3/s

$$S_C = C_{RC}*\frac{1}{R_{hC}}*\frac{V_C^2}{2g} = 0.00378 \quad (38)$$

$$V_C = \frac{Q_C}{A_C} = 0.90\ m/s \quad (24)$$

$$V_C = \sqrt{g*D_C} = 0.90\ m/s \quad (36)$$

$$V_C = \sqrt{\frac{2g}{C_R}*R_{hC}*S_C} = 0.90\ m/s \quad (32)$$

$$V_C = \sqrt{\frac{2g}{f_{W-D}}*R_{hC}*S_C} = 0.90\ m/s \quad (39)$$

VIII. Deducciones

a) *Análisis de la carga de velocidad y las velocidades*

$$h_V = \frac{V_r^2}{2g}\ vs.\ h_V = \propto*\frac{V_m^2}{2g} \rightarrow \alpha*V_m^2 = V_{mr}^2 = \frac{Q^2}{A^2} \rightarrow V_{mr} = \frac{Q}{A} \quad (40)$$

$$V_{mr} = \sqrt{g*D}\,vs.\ V_m = \sqrt{\frac{g*D}{\propto}} \quad (36, 41)$$

$$V_{mr} = \frac{Q}{A} = \sqrt{g*D} = \sqrt{\frac{2g}{C_R}*R_h*S} = \sqrt{\frac{2g}{f_{W-D}}*4R_h*S} \quad (24, 36, 32, 40)$$

$$V_m = \frac{Q}{\sqrt{\propto}*A} = \sqrt{\frac{g*D}{\propto}} = \sqrt{\frac{2g}{\propto*C_R}*R_h*S} = \sqrt{\frac{2g}{\propto*f_{W-D}}*4R_h*S} \quad (42, 41, 43, 44)$$

$$V_{mr} = \frac{Q}{A}(24)V_m = \frac{Q}{\sqrt{\propto}*A} \quad (42)$$

$$V_{mr} = \sqrt{g*D}(37)V_m = \sqrt{\frac{g*D}{\propto}} \quad (41)$$

$$V_{mr} = \sqrt{\frac{2g}{C_R}*R_h*S}(32)V_m = \sqrt{\frac{2g}{\propto*C_R}*R_h*S} \quad (43)$$

$$V_{mr} = \sqrt{\frac{2g}{f_{W-D}}*4R_h*S}(40)V_m = \sqrt{\frac{2g}{\propto*f_{W-D}}*4R_h*S} \quad (44)$$

$$V_{mr} = 0.90\ m/s$$

$$V_m = 0.88\ m/s$$

Observar si $h_V = \propto * \frac{V_m^2}{2g}$ según la bibliografía; entonces, sin lugar a dudas, $\propto * V_m^2 = V_{mr}^2 = \frac{Q^2}{A^2} = \sqrt{\propto} * V_m = V_{mr} = \frac{Q}{A} \rightarrow Q = V_{mr} * A\ y\ no\ \frac{Q}{A} = V_m$, solo la velocidad media real puede ser dividida por el coeficiente α, como también solo la velocidad media puede ser multiplicada por él, es como único existe una corrección de la velocidad, muestra de ello son la similitud de las velocidades en los resultados de las cuatro fórmulas anteriores.

α es un coeficiente de corrección de la carga de velocidad, que surge para eliminar el error que se produce al considerar el término $V_m$como representativo de la media de la distribución real de velocidades que existe en la sección($V_{media} < V_{mreal}$).

b) Ecuación de Bernoulli

$$z_1 + \frac{p_1}{\gamma} + \frac{V_{mr\,1}^2}{2G} = Z_2 + \frac{P_2}{\gamma} + \frac{V_{mr\,2}^2}{2g} + hf_{1-2}(45) V_{mr\,1}\ y\ V_{mr\,2} = \frac{Q}{A} \quad (24)$$

$$z_1 + \frac{p_1}{\gamma} + \alpha_1 * \frac{V_{m\,1}^2}{2g} = Z_2 + \frac{P_2}{\gamma} + \alpha_2 * \frac{V_{m\,2}^2}{2g} + hf_{1-2}(46) V_{m\,1} y\ V_{m\,2} = \frac{Q}{\sqrt{\propto} * A} \quad (42)$$

$$\frac{V_{mr\,1}^2}{2g} = \propto * \frac{V_{m\,1}^2}{2g} \rightarrow V_{m\,1}^2 = \frac{V_{mr\,1}^2}{\propto}\ y\ \frac{V_{mr\,2}^2}{2g} = \propto * \frac{V_{m\,2}^2}{2g} \rightarrow V_{m\,2}^2 = \frac{V_{mr\,2}^2}{\propto}$$

$$V_{m\,1} = \frac{V_{mr\,1}}{\sqrt{\propto}}\ y\ V_{m\,2} = \frac{V_{mr\,2}}{\sqrt{\propto}}$$

Ya que ∝ está implícito en *V*, de la Ecuación de continuidad:

$$Q = V * A \quad (24)$$

Es evidente que $Q = V_{mr} * A = \sqrt{\propto} * V_m * A$

Y no como aparece en la bibliografía. $Q = V * A \rightarrow V = V_m = \frac{Q}{A}$ (24)

c) Ecuación de energía específica, (bibliografía)

$$E_e = y + \alpha * \frac{V_m^2}{2g} = y + \alpha \frac{Q^2}{2g * A^2} \quad (47)$$

Los parámetros *Q* y *A* son valores reales, por ej. Canal experimental Centro Investigaciones Hidráulicas. Ciudad Universitaria José Antonio Echevarría. La Habana. Cuba.

$Q = 0.0297 m^3/s$, entrega constante, por medio de una compuerta plana calibrada y comprobado por aforo.

$h_N = 0.101$m, calculada por el método de tanteo y error en Excel.

$$A = b * h = 0.40 * 0.101 = 0.0404\, m^2$$

$$Q = V * A \rightarrow V = \frac{Q}{A} = 0.735\ m/s y \propto = 1.045$$

Simplemente lo que se hace es aumentar el parámetro de la carga de velocidad en el valor de $\alpha = 1.045$, lo que no tiene fundamento alguno, según lo expuesto en este documento.

Si fuese un problema en que el régimen fuese de un flujo laminar, donde la distribución de velocidades es parabólicay por tanto $\propto = 2$, constante, entonces la carga de velocidad sería el doble de la calculada.

Es decir en vez de:

$$h_V = \frac{V^2}{2g} = \frac{Q^2}{2g * A^2}$$

Sería:

$$h_V = \frac{V^2}{g} = \frac{Q^2}{g * A^2}$$

En Open-Chanel Hydraulics ehidráulica de las conducciones libres, (Chow, 1959; León, 2000), respectivamente, exponen:

$$E_e = y + \alpha * \frac{Q^2}{2g * A^2} \quad (47)$$

Despejando *Q*:

$$Q = \sqrt{\frac{2g}{\propto} * (E_e - y)} * A \quad (48)$$

Entonces se puede plantear:

$$\frac{Q}{A} = \sqrt{\frac{2g}{\propto} * (E_e - y)} = V_m \quad (49)$$

Como α es función de la velocidad:

$$\frac{Q}{A} = \sqrt{2g \times E_e} = \sqrt{\propto} * V_m = V_{mr}$$

Y se llega a:

$$\frac{Q}{\sqrt{\propto}*A} = V_m = \frac{V_{mr}}{\sqrt{\propto}} \quad (42)$$

Es lo que se propone en este artículo.
O lo que es lo mismo, elevando (48) al cuadrado:

$$Q^2 = \left(\sqrt{\frac{2g}{\propto} * (E_e - y)}\right)^2 * A^2 \quad (51)$$

$$\left(\frac{Q}{A}\right)^2 = \frac{2g}{\propto} * (E_e - y) = (V_m)^2 \quad (52)$$

$$(E_e - y) = \propto * \frac{V_m^2}{2g} = \frac{V_{mr}^2}{2g} = \frac{Q^2}{2g*A^2} \quad (53)$$

$$E_e = y + \alpha * \frac{V_m^2}{2g} = \frac{Q^2}{2g*A^2}\text{ ; Correcto} \quad (54)$$

Y no como aparece en la bibliografía, (Chow, 1959; León, 2000), respectivamente, exponen:

$$E_e = y + \alpha * \frac{V_m^2}{2g} = \propto * \frac{Q^2}{2g*A^2}\text{ ; Incorrecto} \quad (47)$$

Observar la fórmula (53):

$$(E_e - y) = \propto * \frac{V_m^2}{2g} = \frac{V_{mr}^2}{2g} = \frac{Q^2}{2g * A^2}$$

$$(E_e - y) = \propto * \frac{V_m^2}{2g}$$

Sustituyendo:

$$\propto * \frac{V_m^2}{2g} = \propto * \frac{V_m^2}{2g} = \frac{V_{mr}^2}{2g} = \frac{Q^2}{2g*A^2} \quad (55)$$

$$\frac{V_{mr}^2}{2g} = \frac{Q^2}{2g*A^2} \rightarrow Q = \frac{V_{mr}}{A} \rightarrow V_{mr} = \frac{Q}{A} \quad (24)$$

IX. Comentarios

Observar.

$$E_e = y + \alpha * \frac{V_m^2}{2g} = y + \alpha * \frac{Q^2}{2g*A^2}\text{ Vs. } E_e = y + \frac{V_{mr}^2}{2g} = + \frac{Q^2}{2g*A^2}$$

$hf = C_R * \frac{L}{R_h} * \frac{V^2}{2g} = f_{W-D} * \frac{L}{D_i} * \frac{V^2}{2g} = 4C_R * \frac{L}{4R} * \frac{V^2}{2g}$; Ley general de la resistencia fluida, de ella se obtiene.

$$(E_e - y) = \frac{S * R_h}{C_r} = \frac{S * D_i}{f_{W-D}} = \frac{S * 4R_h}{4C_R}$$

(No contempla a α).

¿Cómo es posible que para $\propto = 1$, la velocidad media V **media**, sea mayor que para $\propto > 1$, $\left(V_m = \sqrt{g * D} > V_m = \sqrt{\frac{g*D}{\propto}}\right)$, respectivamente? Si precisamente el coeficiente $\propto$es para corregirla. Es decir, en todo caso sería:

$$\left(V_{mr} = \sqrt{g * D} > V_m = \sqrt{\frac{g * D}{\propto}}\right)$$

$$V_m = \sqrt{\frac{g * D}{\propto}} \rightarrow \alpha * V_m = \sqrt{g * D} = V_{mr}$$

Si se tiene un gasto constante y establecido (masa de líquido continua y compacta), en el que no existan burbujas de aire ni cualquier otro factor que influya en la normal circulación de éste a través de una tubería de diámetro constante o variable (telescópica), cualquiera que sea la distribución de velocidades en ella, la que por cierto es invariable en toda la longitud de la conducción, la relación del gasto entre el área, es uno y solo un valor, que es la velocidad media real, como se demostró en el ejemplo1, figura 1, tubería telescópica, (diámetro variable), donde cada uno de ellos, tienen velocidades *V* y coeficientes **α** diferentes.

V_{mr1} = 0.02m/s *vs*. V_{m1} = 0.01414m/s; V_{mr2} = 0.08m/s *vs*.

V_{m2} = 0.0762m/s, y V_{mr3} = 2.0m/s *vs*.V_{m3} = 1.87m/s, así, como α_1 = 2, α_2 = 1.1028, α_3 = 1.1445, distribución parabólica para α_1, y logarítmica para, α_2, α_3, a pesar de lo cual se sigue cumpliendo, la ecuación de continuidad.

La bibliografía consultada expone que para canales rectos y uniformes el coeficiente **α** de Coriolis está entre 1.03 y 1.36.

La antigua Unión Soviética y Holanda, países pioneros de la hidráulica, generalmente para el diseño de las obras, tuberías y canales, asumen **α** = 1.10.

En la Tabla 1 se muestran los valores de **α** y **β**, obtenidos por Kolupaila en su investigación, Se puede observar la notable variación entre los valores del coeficiente de Coriolis **α** (Chow, 1959; León, 2000).

Tabla 1: Datos de α y β para algunos canales obtenidos por Kolupailay referenciados por Chow (1959).

Canales	Valores de α			Valores de β		
	Mín	Prom	Máx	Mín	Prom	Máx
Canales regulares, canaletas y vertedores	1.10	1.15	1.20	1.03	1.05	1.07
Corrientes naturales y torrentes	1.15	1.30	1.50	1.05	1.10	1.17
Ríos bajo cubierta de hielo	1.20	1.50	2.00	1.07	1.17	1.33
Valles de ríos inundados	1.50	1.75	2.00	1.17	1.25	1.33

Chow (1959:pág. 28) presenta valores de∝, de 2,08, 3.87 y 7.40, de ahí la necesidad de su correcta aplicación.

La ley que fue posteriormente modificada por Einstein en la ley de conservación de la energía de masas, consiste en una descripción del hecho de que la masa total y la energía en un sistema permanecen constantes. Esta enmienda incorpora el hecho de que la masa y la energía se pueden convertir de una a otra.

De acuerdo con las leyes de la conservación de la materia o de la masa y de la energía, éstas ni se crean ni se destruyen, solo se transforman. En nuestro caso el gasto másico que entra es igual al gasto másico que sale.

Gasto másico:

$$dm = \rho * V * dA \tag{54}$$

Integrando:

$$m = \rho * V * A \tag{55}$$

Para el agua, $\rho = 1$

Por tanto:

$$m = V * A \tag{56}$$

V = velocidad del fluido.

Hay que ser consecuentes con los planteamientos.

Si es cierto que el coeficiente α de Coriolis influye en la carga de velocidad y este es mayor que la unidad por definición, entonces hay que aplicarlo, para obtener los resultados más próximos del fenómeno investigado.

Para los problemas hidráulicos, donde el flujo es turbulento, generalmente se considera que α = 1. A pesar de que esta suposición no es correcta, por lo antes expuesto, los resultados son correctos, porque lo cierto es que él no influye en los cálculos.

La cuestión está en el caso, en que el problema, sea de un flujo laminar donde, el coeficiente α, en cuyo caso, según la bibliografía, la carga de velocidad sería dos veces la calculada ($h = V^2/g$ en vez de $h = V^2/2g$).

Las fórmulas (11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 29 y 33), fueron propuestas por el que suscribe en el artículo "Fórmulas generales para los coeficientes de Chezy y de Manning" y las fórmulas (42, 43, 44, 49 y 53), son las propuestas en esta investigación.

El autor de esta propuesta reconoce que ha sido repetitivo e insistente en la redacción de este documento, pero no es fácil rebatir algo que ha sido reconocido y aplicado, por mucho tiempo y por innumerables conocedores del tema con sobrada experiencia y conocimientos.

Se necesita mente abierta y sin prejuicios para poder avanzar, en cualquier campo del conocimiento, porque no todo lo que nos enseñan y que se da por verdadero es correcto.

Los objetivos principales del conocimiento científico y de la ciencia son, alcanzar la verdad objetiva y obtener resultados más veraces y precisos, respectivamente.

Relación de parámetros:

Q: gasto (m^3/s).

V_{mr}: velocidad media real (m/s).

V_m: velocidad media (m/s).

V_C: velocidad crítica (m/s).

A: área (m^2).

R_h: radio hidráulico (m).

S: pendiente (Adim).

D_i: diámetro interior (m).

$h_N = y_N$: profundidad normal (m).

$h_C = y_C$: profundidad crítica (m).

P: profundidad hidráulica (m).

h_f: pérdidas de carga lineal (m).

E_C: energía cinética (m).

Z: energía potencial (m).

P/γ : energía de presión (m).

R_e: número de Reynolds (adim).

F_R: número de Froude (adim).

f_{W-D}: coeficiente de Weisbach-Darcy (adim).

C_R: coeficiente de la resistencia fluida (adim).

α Y α: coeficiente Coriolis (adim).

β: coeficiente de Boussinesq (adim).

ν : Viscosidad cinemática (m^2/s).

γ : Peso específico (kgf/m^3).

ρ : Densidad del fluido (kg/m^3)

g: gravedad (m/s^2).

X. Conclusiones

1. El coeficiente **α**, de Coriolis no tiene influencia alguna sobre la carga de velocidad, porque él está implícito en el parámetro velocidad y/o en el parámetro gasto, de lasecuaciones de continuidad y Bernoulli. (Principios de conservación de la masa y la energía), respectivamente, aplicadas al flujo de fluidos.

$$Q = V * A$$

$$E_e = y + \frac{V_{mr}^2}{2g} = \frac{Q^2}{2g * A^2}$$

2. Definir el concepto de velocidad media real como:

$$\mathrm{V_{mreal}} = \frac{\mathrm{Q}}{\mathrm{A}}$$

3. Redefinir el concepto de velocidad media como:

$$\mathrm{V_{media}} = \frac{\mathrm{V_{mreal}}}{\sqrt{\alpha}} = \frac{\mathrm{Q}}{\sqrt{\propto} * \mathrm{A}}$$

Agradecimientos

Mis infinitos agradecimientos al amigo y colega, MSc. Ing. Alberto Díaz Ordaz, por haber revisado, hacer arreglos y dar consejos muy valiosos, sin los cuales me hubiese sido muy difícil llevar a feliz término esta investigación.

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Notas:

1. La masa es energía y viceversa. Una se transforma en la otra.

$$E = m \times C^2 \rightarrow \frac{E}{m} = C^2$$

La relación entre la masa y la energía es una constante, que es la Velocidad de la luz al cuadrado, ($C \cong 300\,000\ km/s$).

2. Se puede demostrar que las ecuaciones de continuidad y Bernoulli, (masa y energía), son una misma.
3. Es muy posible que existan deficiencias en las normas de Global Journal y la redacción. Dejo a su disposición cualquier cambio al respecto.

Espero acuse de recibo.
Cordiales saludos.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Colored Quark and Colored Gluon in Standard Model, Hadronic Constituents

By ShaoXu Ren
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Abstract-

In current particle physics, *Color* of a particle and *Spin* of this particle belong to different space, and researches on hadronic constituents are going under this guidance. In this paper base on color representation of flavor t, c, u, d, s, b of quarks and their antiquarks, color and spin are postulated to be combined into a common space STS. In this space, quark and gluon can be turned into *colored quark* and *colored gluon* directly by being colored with quark colors $q_{\mathrm{R}}, q_{\mathrm{G}}, q_{\mathrm{B}}$ and antiquark colors $\bar{q}_{\bar{\mathrm{R}}}, \bar{q}_{\bar{\mathrm{G}}}, \bar{q}_{\bar{\mathrm{B}}}$.

Keywords: quark color, gulon color, colored quark, colored gluon, gluon corlor matrix, spin-color state, charmed colored baryon SU(4), gluon ground state, gluon excited state, observable experimental baryon and meson.

GJSFR-A Classification: *MSC: 81V05, 81V10, 81V15, 81V20*

COLOREDQUARKANDCOLOREDGLUONINSTANDARDMODELHADRONICCONSTITUENTS

Strictly as per the compliance and regulations of:

Colored Quark and Colored Gluon in Standard Model, Hadronic Constituents

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Abstract-

In current particle physics, *Color* of a particle and *Spin* of this particle belong to different space, and researches on hadronic constituents are going under this guidance. In this paper base on color representation of flavor t, c, u, d, s, b of quarks and their antiquarks, color and spin are postulated to be combined into a common space STS. In this space, quark and gluon can be turned into *colored quark* and *colored gluon* directly by being colored with quark colors $q_{\mathsf{R}}, q_{\mathsf{G}}, q_{\mathsf{B}}$ and antiquark colors $\overline{q}_{\overline{\mathsf{R}}}, \overline{q}_{\overline{\mathsf{G}}}, \overline{q}_{\overline{\mathsf{B}}}$. Along with such idea of hadronic constituents, Consequently we have:

For observed baryon constituent: *colored baryon* particle and force-mediating *colored gluon* particle.
For observed meson constituent: *colored meson* particle and force-mediating *colored gluon* particle..

The above process of the color role related to hadronic constituents in this paper are much different from that of current SU(3)$_{\text{color}}$. And total spin $\mathsf{S}_3(qqq, qqq_{\text{color}})$ of *colored baryon* could be one-third series. And total spin $\mathsf{S}_3(q\overline{q}, q\overline{q}_{\text{color}})$ of *colored meson* could be zero, integer, even half-integer. Although the phenomenons of such S_3 may not be observed.

Colored pseudoscalar meson and colored vector meson separately are singlet and triplet of spin-color state $\mathbb{R}(q\overline{q}; \alpha, \overline{\alpha})$, when *colored gluons* occupy color ground state $(0, 0)$.

Colored scalar meson and colored pseudovector meson separately are singlet and triplet of spin-color state $\mathbb{R}(q\overline{q}; \alpha, \overline{\beta})$, when *colored gluons* transfer to color excited state (ξ_1, ξ_2), $\xi = \xi_1 + \xi_2 \neq 0$.

The above introduction of gluon corlor ground state $(0, 0)$ and gluon corlor excited state (ξ_1, ξ_2) instead of orbital angular momentums $L = 0$ and $L = 1$ of quarks in current theory.

Possible new flovors $\mathsf{X}_1, \mathsf{X}_2, \mathsf{X}_3$ and $\mathsf{Y}_1, \mathsf{Y}_2, \mathsf{Y}_3$ are incidental to this paper. Multiquark hadrons constituents may refer this paper work too

Keywords: quark color, gulon color, colored quark, colored gluon, gluon corlor matrix, spin-color state, charmed colored baryon SU(4), gluon ground state, gluon excited state, observable experimental baryon and meson

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Contents

0. Introduction

Hadronic constituents is an amusing topic in particle physics, there are many expeditionary ways to approach to this puzzle [1]. QCD provides powerful methods, and bases on $SU(3)_{\text{color}}$ many great studies are going around in this domain [2]

In this paper we offer a new idea of color concept: Three colors, ren R, green G and blue B that range from "visible light" are extended to optical "color spectrum" of flavor $q^r_{\text{RGB}}=(q_{\text{R}}, q_{\text{G}}, q_{\text{B}})$ [3]. Diffrent flavor could possess same color α, but occupies different "wavelength" q_α. Then all flavors are unified into a common isospin space and become the discrete function of R, G and B. Along with this way, we are going to discuss hadronic constituents following.

The structure of this paper includes four parts: Part.A Quark, Part.B Gluon, Part.C Baryon and Part.D Meson.

Part.A: Table.1 is of the essence, "color spectrum" $q^r_{\text{RGB}}=(q_{\text{R}}, q_{\text{G}}, q_{\text{B}})$ is endowed with one-sixth spin series $\pi_3(q)$ [4],[5], $q_{\text{R}}, q_{\text{G}}, q_{\text{B}}$ named as *quark color* q_α $\alpha=\text{R, G, B}$, which are values of three color components of a quark q respectively. the algebre sum $q(\chi,\alpha)$, of spin angular momentum $q(\chi)$ $(\chi=\uparrow,\downarrow)$ of quark q and quark color q_α of the quark, is the value of *colored quark* (for convience, sometime colored baryons are labelled by symbol $qqq + qqq_{\text{color}}$). And Table.2 shows colored quark possesses properties of one-third series. Because colored baryons are comprised of three colored quarks, so introduce *spin-color state* that an array of the colored quarks $q(\chi,\alpha)$. Further by *spin-color state* representation $\{q(\chi,\alpha), \bar{q}(\chi,\beta), q(\chi,\gamma)\}$ (Figure.2) of $qqq + qqq_{\text{color}}$ colored baryon, $S_3(qqq, qqq_{\text{color}})^*$ (Figure.3) of charmed colored baryons is obtained.

Part.B: Detailed research work of preliminary to *colored gluon* $g(\alpha\bar{\beta})$ is given. *colored gluon* (section.5*) is more complex than *colored quark*(section.2*). Quark color only needs a single quantum number q_α (in Table.1), however gluon color $g_{\alpha\bar{\beta}}$ (7) includes two quantum numbers q_α and $\bar{q}_{\bar{\beta}}$, which related to both quark q and antiquark $\bar{q}$. Detailed gluon color $g_{\alpha\bar{\beta}}$ are provided in Table.4, which are frequently quoted in most calculations of this paper. And for the beauties of math symmetry, we transform Table.4 into Table.5 gluon color matrix $\alpha\beta M$, this matrix can give conveniences in dealing with variety of gluon state.

Part.C: Based on both color ground state $g(qqq,0)_{\text{color}} = (0,0,0)$ to obtain spin $S_3(ggg, g(qqq.0)_{\text{color}})$ of corlored gluon of charmed SU(4) (Figure.7). Then use colored baryon $S_3(qqq, qqq_{\text{color}})^*$ and colored gluon $S_3(ggg, g(qqq.0)_{\text{color}})$ by formular (11) get $S_3(qqq, \text{experiment})_{[1]}$ of observed baryons. Another quivalent way to observed baryons is $S_3(qqq, \text{experiment})_{[2]}$, by considering *spin coupling* $qqq + ggg$ between quark qqq and gluon $ggg(qqq)$ to get $S_3(qqq, ggg)$. And considering *color coupling* $qqq_{\text{color}} + ggg_{\text{color}}$ between quark qqq_{color} and gluon ggg_{color} to get $S_3(qqq_{\text{color}}, ggg_{\text{color}})$.

Part.D: By four spin-color states $\{q(\uparrow,\alpha), \bar{q}(\downarrow,\bar{\beta})\}$, $\{q(\downarrow,\alpha), \bar{q}(\uparrow,\bar{\beta})\}$, $\{q(\uparrow,\alpha), \bar{q}(\uparrow,\bar{\beta})\}$, $\{q(\downarrow,\alpha), \bar{q}(\downarrow,\bar{\beta})\}$ (14.0) of $q\bar{q} + q\bar{q}_{\text{color}}$ colored meson, discuss formation of observed pseudoscalar mesons, vector mesons (Table.11 corlor ground state $g(q\bar{q},0)_{\text{color}} = (0,0)$ 《**A**》) and that of observed scalar mesons, pseudovector mesons (Table.12 corlor excited state $g(q\bar{q})_{\text{color}} \neq (0,0)$ 《**B**》)

Global Journal of Science Frontier Research (A) Volume XXIII Issue II Version I Year 2023

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Two tables below depict the outline of idea of color in particle physics that presented in this paper

colored baryon	colored gluon	||	colored meson	colored gluon
total angular momentum	total angular momentum	||	total angular momentum	total angular momentum
$qqq + qqq_{\text{color}}$	$ggg + ggg_{\text{color}}$	||	$q\bar{q} + q\bar{q}_{\text{color}}$	$gg + gg_{\text{color}}$
spin angular momentum	spin angular momentum	||	spin angular momentum	spin angular momentum
qqq	ggg	||	$q\bar{q}$	gg
color angular momentum	color angular momentum	||	color angular momentum	color angular momentum
qqq_{color}	ggg_{color}	||	$q\bar{q}_{\text{color}}$	gg_{color}

Table 0.1: angular momentum elements of colored baryon, colored gluon (left) and of colored meson, colored gluon (right)

	observed baryon		||		observed meson	
	$S_3(qqq,$ experimental $)$		||		$S_3(q\bar{q},$ experimental $)$	
	↙↙	↘↘		↙↙	↘↘	
colored baryon		colored gluon	||	colored meson		colored gluon
$S_3(qqq, qqq_{\text{color}})$		$S_3(ggg, ggg_{\text{color}})$	||	$S_3(q\bar{q}, q\bar{q}_{\text{color}})$		$S_3(gg, gg_{\text{color}})$

Table 0.2: formations of observed baryon (left) and formation of observed meson (right)

$S_3(qqq,$ experimental $)$ of observed baryon consists of $S_3(qqq, qqq_{\text{color}})$ of colored baryon and $S_3(ggg, ggg_{\text{color}})$ of colored gluon, here gluon color $ggg_{\text{color}} = ggg_{\text{color}}(qqq) \equiv g(qqq)_{\text{color}}$ is associated with the baryon qqq.

$S_3(q\bar{q},$ experimental $)$ of observed meson consists of $S_3(q\bar{q}, q\bar{q}_{\text{color}})$ of colored meson and $S_3(gg, gg_{\text{color}})$ of colored gluon, here gluon color $gg_{\text{color}} = gg_{\text{color}}(q\bar{q}) \equiv g(q\bar{q})_{\text{color}}$ is associated with the meson $q\bar{q}$.

Part.A Quark

1. Color Representation of Flavor

In current **Standard Model SM**, six fundamental quarks r or ω (t, c, u, d, s, b) $\{\ \bar{r}$ or $\bar{\omega}$ $(\bar{t}, \bar{c}, \bar{u}, \bar{d}, \bar{s}, \bar{b})\ \}$ are assigned to five different flavor isospin spaces. Among them, quarks u and d to an isodoublet with $I = 1/2$, remaining four quarks t, c, s, b to isosinglet with $I = 0$ in one of four different flavor isospin spaces respectively. Paper [3] assumes these six quarks could be unified into a common isospin multiplets space. Every one of the six quarks is with $I = 1/2$ in math frame **Spin Topological Space STS**. Base on **Pauli Exclusion Principle**, their flavours could be labelled by the third component of each quark $I_3(t)=\frac{+5}{2}, I_3(c)=\frac{+3}{2}, I_3(u)=\frac{+1}{2}, I_3(d)=\frac{-1}{2}, I_3(s)=\frac{-3}{2}, I_3(b)=\frac{-5}{2}$ respectively. Here the physical concept of flavor r of a quark is supposed to be related to so-called **Colour Spectrum Diagram of Flavour CSDF.**

In this paper more advanced understanding of **CSDF** is offered, which is expressed in Table.1 below. And we will use this table to research for the structure of hadrons later paragraphs. Where $q^r_{\mathrm{RGB}}=(q_{\mathrm{R}}, q_{\mathrm{G}}, q_{\mathrm{B}})$ is color spectral line array of flavor r, by which, the concrete values $I_3(q)$ of isospin of quark q could be obtained. The concrete values q_α $(\alpha = \mathrm{R,G,B})$ of q^r_{RGB} are given from one-sixth spin series $\pi_3(q), \vec{\pi}(q)$ [4],[5]

$$\pi_3(q) = \ldots, \underline{\frac{-29}{6}, \frac{-23}{6}, \frac{-17}{6}, \frac{-11}{6}, \frac{-5}{6}}, \underline{\frac{+1}{6}, \frac{+7}{6}, \frac{+13}{6}, \frac{+19}{6}, \frac{+25}{6}}, \ldots \tag{1}$$

$$\vec{\pi}(q) \times \vec{\pi}(q) = i\vec{\pi}(q) \tag{2}$$

and

$$I_3(q) = \frac{1}{3}(q_{\mathrm{R}} + q_{\mathrm{G}} + q_{\mathrm{B}}) \tag{3.1}$$

$$I_3(\bar{q}) = \frac{1}{3}(\bar{q}_{\bar{\mathrm{R}}} + \bar{q}_{\bar{\mathrm{G}}} + \bar{q}_{\bar{\mathrm{B}}}) \tag{3.2}$$

$q_{\mathrm{R}}, q_{\mathrm{G}}, q_{\mathrm{B}}$ are called as *quark color* and $\bar{q}_{\bar{\mathrm{R}}}, \bar{q}_{\bar{\mathrm{G}}}, \bar{q}_{\bar{\mathrm{B}}}$ as *antiquark color.*

quark flavor r	t			c			u			d			s			b		
$I_3(q)$	$I_3(t)$	$\frac{+5}{2}$		$I_3(c)$	$\frac{+3}{2}$		$I_3(u)$	$\frac{+1}{2}$		$I_3(d)$	$\frac{-1}{2}$		$I_3(s)$	$\frac{-3}{2}$		$I_3(b)$	$\frac{-5}{2}$	
q_α	t_R	t_G	t_B	c_R	c_G	c_B	u_R	u_G	u_B	d_R	d_G	d_B	s_R	s_G	s_B	b_R	b_G	b_B
q^r_{RGB}	$\frac{+7}{6}$	$\frac{+13}{6}$	$\frac{+25}{6}$	$\frac{+1}{6}$	$\frac{+7}{6}$	$\frac{+19}{6}$	$\frac{-5}{6}$	$\frac{+1}{6}$	$\frac{+13}{6}$	$\frac{-11}{6}$	$\frac{-5}{6}$	$\frac{+7}{6}$	$\frac{-17}{6}$	$\frac{-11}{6}$	$\frac{+1}{6}$	$\frac{-23}{6}$	$\frac{-17}{6}$	$\frac{-5}{6}$
	$t_R+t_G+t_B$	$\frac{+45}{6}=\frac{+15}{2}$		$c_R+c_G+c_B$	$\frac{+27}{6}=\frac{+9}{2}$		$u_R+u_G+u_B$	$\frac{+9}{6}=\frac{+3}{2}$		$d_R+d_G+d_B$	$\frac{-9}{6}=\frac{-3}{2}$		$s_R+s_G+s_B$	$\frac{-27}{6}=\frac{-9}{2}$		$b_R+b_G+b_B$	$\frac{-45}{6}=\frac{-15}{2}$	
anti-quark flavor $\bar{r}$	$\bar{t}$			$\bar{c}$			$\bar{u}$			$\bar{d}$			$\bar{s}$			$\bar{b}$		
$I_3(\bar{q})$	$I_3(\bar{t})$	$\frac{-5}{2}$		$I_3(\bar{c})$	$\frac{-3}{2}$		$I_3(\bar{u})$	$\frac{-1}{2}$		$I_3(\bar{d})$	$\frac{+1}{2}$		$I_3(\bar{s})$	$\frac{+3}{2}$		$I_3(\bar{b})$	$\frac{+5}{2}$	
$\bar{q}_{\bar{\alpha}}$	$\bar{t}_{\bar{R}}$	$\bar{t}_{\bar{G}}$	$\bar{t}_{\bar{B}}$	$\bar{c}_{\bar{R}}$	$\bar{c}_{\bar{G}}$	$\bar{c}_{\bar{B}}$	$\bar{u}_{\bar{R}}$	$\bar{u}_{\bar{G}}$	$\bar{u}_{\bar{B}}$	$\bar{d}_{\bar{R}}$	$\bar{d}_{\bar{G}}$	$\bar{d}_{\bar{B}}$	$\bar{s}_{\bar{R}}$	$\bar{s}_{\bar{G}}$	$\bar{s}_{\bar{B}}$	$\bar{b}_{\bar{R}}$	$\bar{b}_{\bar{G}}$	$\bar{b}_{\bar{B}}$
$\bar{q}^{\bar{r}}_{\overline{RGB}}$	$\frac{-7}{6}$	$\frac{-13}{6}$	$\frac{-25}{6}$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$	$\frac{+5}{6}$	$\frac{-1}{6}$	$\frac{-13}{6}$	$\frac{+11}{6}$	$\frac{+5}{6}$	$\frac{-7}{6}$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$\frac{+23}{6}$	$\frac{+17}{6}$	$\frac{+5}{6}$
	$\bar{t}_{\bar{R}}+\bar{t}_{\bar{G}}+\bar{t}_{\bar{B}}$	$\frac{-45}{6}=\frac{-15}{2}$		$\bar{c}_{\bar{R}}+\bar{c}_{\bar{G}}+\bar{c}_{\bar{B}}$	$\frac{-27}{6}=\frac{-9}{2}$		$\bar{u}_{\bar{R}}+\bar{u}_{\bar{G}}+\bar{u}_{\bar{B}}$	$\frac{-9}{6}=\frac{-3}{2}$		$\bar{d}_{\bar{R}}+\bar{d}_{\bar{G}}+\bar{d}_{\bar{B}}$	$\frac{+9}{6}=\frac{+3}{2}$		$\bar{s}_{\bar{R}}+\bar{s}_{\bar{G}}+\bar{s}_{\bar{B}}$	$\frac{+27}{6}=\frac{+9}{2}$		$\bar{b}_{\bar{R}}+\bar{b}_{\bar{G}}+\bar{b}_{\bar{B}}$	$\frac{+45}{6}=\frac{+15}{2}$	

Table 1: Fundamental Color Representation of flavor t, c, u, d, s, b of quarks and their antiquarks

2. Colored Quark $q(x, a)$

In current **Standard Model SM** baryon consists of three quarks, meson is comprised of a quark and an antiquark; baryons and mesons are observable, as colorless. quarks and antiquarks are unobservable because of their colorful. Color can't be observable, i.e. so-called color confinement phenomenon. In a word, we could not observe spin 1/2 quark particle q nor observe quark color q_α.

In this paper an ides of so-called *colored quark* labelled $q(\chi,\alpha)$ is suggested: colorless angular momentum spin 1/2 quark particle q turns into colorful by directly being colored by quark color q_α, which is the algebra sum (4.0) of colorless *quark spin* q or $q(\uparrow), q(\downarrow)$ and *quark corlor* q_α, q_β (q^r_{RGB})

$$\textit{colored quark } q(\chi,\alpha) : \qquad q(\chi,\alpha) = q(\chi) + q_\alpha \quad \text{with } \chi=\uparrow,\downarrow \tag{4.0}$$

First we consider a special case (4), later on, in Part.D, back to (4.0)

$$q=t, c, u \text{ are limited with } \chi=\uparrow; \quad q(\chi,\alpha) = q(\chi) + q_\alpha = q(\uparrow,\alpha) = q(\uparrow) + q_\alpha,$$

$$q=b, s, d \text{ are limited with } \chi=\downarrow; \quad q(\chi,\beta) = q(\chi) + q_\beta = q(\downarrow,\beta) = q(\downarrow) + q_\beta \qquad \alpha, \beta, = \mathrm{R,G,B} \tag{4}$$

As examples of (4), for colored quark u

$$\text{colored red } up \text{ quark} \qquad u(\uparrow,\mathrm{R}) = u(\uparrow) + u_\mathrm{R} = \frac{+1}{2} + \frac{-5}{6} = \frac{+3}{6} + \frac{-5}{6} = \frac{-2}{6} = \frac{-1}{3} \tag{4.1}$$

$$\text{colored green } up \text{ quark} \qquad u(\uparrow,\mathrm{G}) = u(\uparrow) + u_\mathrm{G} = \frac{+1}{2} + \frac{+1}{6} = \frac{+3}{6} + \frac{+1}{6} = \frac{+4}{6} = \frac{+2}{3} \tag{4.2}$$

$$\text{colored blue } up \text{ quark} \qquad u(\uparrow,\mathrm{B}) = u(\uparrow) + u_\mathrm{B} = \frac{+1}{2} + \frac{+13}{6} = \frac{+3}{6} + \frac{+13}{6} = \frac{+16}{6} = \frac{+8}{3} \tag{4.3}$$

Formula (4) shows spin values $q(\chi,\alpha)$ (the third components) of colored quark u possess one-third series fraction property.

【***Emphasis***】 in current theory, color identities of particles are thought to adhere to $SU(3)_{\mathrm{color}}$. *Color* and *Spin* belong to different spaces. However, in contrast, according to definition (4.0), *quark corlor* q_α, q_β and *quark spin* $q(\uparrow), q(\downarrow)$ belong to a common space STS, Spin Topological Space.

We extend colored *up* quarks (4.1),(4.2),(4.3) to all six flavors, then obtain Table.2 $q(\chi,\alpha)$ for six colored quarks.

flavor r				t			c			u		
$q(\uparrow)$	spin $\uparrow$			$t(\uparrow)$ $\frac{+1}{2}$			$c(\uparrow)$ $\frac{+1}{2}$			$u(\uparrow)$ $\frac{+1}{2}$		
q^r_{RGB}			t_{R} $\frac{+7}{6}$	t_{G} $\frac{+13}{6}$	t_{B} $\frac{+25}{6}$	c_{R} $\frac{+1}{6}$	c_{G} $\frac{+7}{6}$	c_{B} $\frac{+19}{6}$	u_{R} $\frac{-5}{6}$	u_{G} $\frac{+1}{6}$	u_{B} $\frac{+13}{6}$	
colored quark	$q(\chi,\alpha)$	★	$t(\uparrow,\mathrm{R})$ $\frac{+5}{3}$	$t(\uparrow,\mathrm{G})$ $\frac{+8}{3}$	$t(\uparrow,\mathrm{B})$ $\frac{+14}{3}$	$c(\uparrow,\mathrm{R})$ $\frac{+2}{3}$	$c(\uparrow,\mathrm{G})$ $\frac{+5}{3}$	$c(\uparrow,\mathrm{B})$ $\frac{+11}{3}$	$u(\uparrow,\mathrm{R})$ $\frac{-1}{3}$	$u(\uparrow,\mathrm{G})$ $\frac{+2}{3}$	$u(\uparrow,\mathrm{B})$ $\frac{+8}{3}$	★
———	• •			———		•	———		•	———		
flavor r				b			s			d		
$q(\downarrow)$	spin $\downarrow$			$b(\downarrow)$ $\frac{-1}{2}$			$s(\downarrow)$ $\frac{-1}{2}$			$d(\downarrow)$ $\frac{-1}{2}$		
q^r_{RGB}			b_{R} $\frac{-23}{6}$	b_{G} $\frac{-17}{6}$	b_{B} $\frac{-5}{6}$	s_{R} $\frac{-17}{6}$	s_{G} $\frac{-11}{6}$	s_{B} $\frac{+1}{6}$	d_{R} $\frac{-11}{6}$	d_{G} $\frac{-5}{6}$	d_{B} $\frac{+7}{6}$	
colored quark	$q(\chi,\alpha)$	★	$b(\downarrow,\mathrm{R})$ $\frac{-13}{3}$	$b(\downarrow,\mathrm{G})$ $\frac{-10}{3}$	$b(\downarrow,\mathrm{B})$ $\frac{-4}{3}$	$s(\downarrow,\mathrm{R})$ $\frac{-10}{3}$	$s(\downarrow,\mathrm{G})$ $\frac{-7}{3}$	$s(\downarrow,\mathrm{B})$ $\frac{-1}{3}$	$d(\downarrow,\mathrm{R})$ $\frac{-7}{3}$	$d(\downarrow,\mathrm{G})$ $\frac{-4}{3}$	$d(\downarrow,\mathrm{B})$ $\frac{+2}{3}$	★

Table 2: $q(\chi,\alpha)$ of colored quark

Because every colored baryon consists of three colored quarks, so colored baryon could be written as an array of three colored quarks $q(\chi,\alpha)$. Following Figure.1 is the physical frame of charmed baryon SU(4), we are going to use three $q(\chi,\alpha)$ to find out representation of colored baryon $qqq + qqq_{\mathrm{color}}$ SU(4) below.

3. Spin - Color State, Spin of Colored Baryon $qqq + qqq_{color}$ SU(4)

- ♣ *Spin-Color State* of Colored baryon is an array of three colored quarks $q(\chi,\alpha)$ that come from formula (4)
- ♣ Colored baryon is expressed by *spin-color state* by $\{q(\chi,\alpha), \bar{q}(\chi,\beta), q(\chi,\gamma)\}$, $\chi = \uparrow, \downarrow$, α, β, γ = R,G,B..

Examples of spin-color states for baryon composites are following:

$$\text{For baryon } \Delta^{++} \equiv \Delta^{++}_{\mathrm{uuu}}: \quad S_3(\mathrm{uuu}, \mathrm{uuu}_{\mathrm{color}}) \equiv S_3(\Delta^{++}) = S_3(\mathrm{uuu}) = \frac{1}{3}\{u(\uparrow, \mathrm{R}) + u(\uparrow, \mathrm{G}) + u(\uparrow, \mathrm{B})\} = \frac{1}{3}\left\{\frac{-1}{3}, \frac{+2}{3}, \frac{+8}{3}\right\} = \frac{1}{3}\left\{\frac{+9}{3}\right\} = \frac{+3}{3} \tag{5.1}$$

$$\text{For baryon } \Xi^{*0}_{\mathrm{c}} \equiv \Xi^{0}_{\mathrm{cds}}: \quad S_3(\mathrm{cds}, \mathrm{cds}_{\mathrm{color}}) \equiv S_3(\Xi^{*0}_{\mathrm{c}}) = S_3(\mathrm{cds}) = \frac{1}{3}\{c(\uparrow, \mathrm{R}) + d(\downarrow, \mathrm{G}) + s(\downarrow, \mathrm{B})\} = \frac{1}{3}\left\{\frac{+2}{3}, \frac{-4}{3}, \frac{-1}{3}\right\} = \frac{1}{3}\left\{\frac{-3}{3}\right\} = \frac{-1}{3} \tag{5.2}$$

In this way, we transform charmed baryon SU(4) Figure.1 into spin-color state of charmed corored baryon $qqq + qqq_{\mathrm{color}}$ SU(4) Figure.2

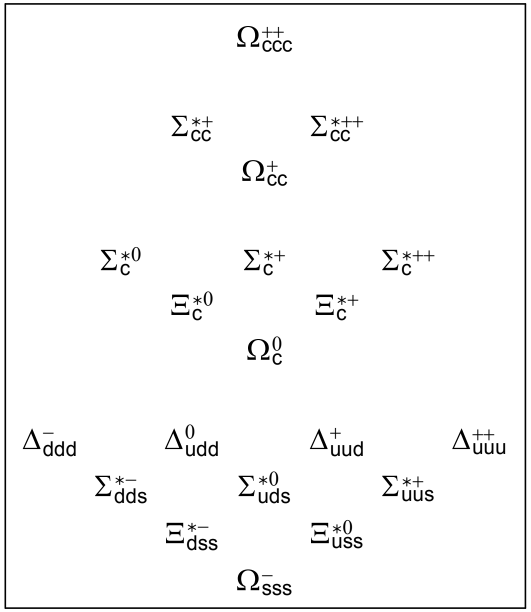

Figure 1: Math frame of charmed baryon SU(4)

$c(\uparrow, \mathrm{R}), c(\uparrow, \mathrm{G}), c(\uparrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+5}{3}, \frac{+11}{3}\right) \quad \frac{+18}{3}$

$c(\uparrow, \mathrm{R}), c(\uparrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+5}{3}, \frac{+2}{3}\right) \quad \frac{+9}{3}$

$c(\uparrow, \mathrm{R}), c(\uparrow, \mathrm{G}), u(\uparrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+5}{3}, \frac{+8}{3}\right) \quad \frac{+15}{3}$

$c(\uparrow, \mathrm{R}), c(\uparrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+5}{3}, \frac{-1}{3}\right) \quad \frac{+6}{3}$

$c(\uparrow, \mathrm{R}), d(\downarrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{-4}{3}, \frac{+2}{3}\right) \quad \frac{0}{3}$

$c(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+2}{3}, \frac{+2}{3}\right) \quad \frac{+6}{3}$

$c(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), u(\uparrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+2}{3}, \frac{+8}{3}\right) \quad \frac{+12}{3}$

$c(\uparrow, \mathrm{R}), d(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{-4}{3}, \frac{-1}{3}\right) \quad \frac{-3}{3}$

$c(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{+2}{3}, \frac{-1}{3}\right) \quad \frac{+3}{3}$

$c(\uparrow, \mathrm{R}), s(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{+2}{3}, \frac{-7}{3}, \frac{-1}{3}\right) \quad \frac{-6}{3}$

$d(\downarrow, \mathrm{R}), d(\downarrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{-7}{3}, \frac{-4}{3}, \frac{+2}{3}\right) \quad \frac{-9}{3}$

$u(\uparrow, \mathrm{R}), d(\downarrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{-4}{3}, \frac{+2}{3}\right) \quad \frac{-3}{3}$

$u(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), d(\downarrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{+2}{3}, \frac{+2}{3}\right) \quad \frac{+3}{3}$

$u(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), u(\uparrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{+2}{3}, \frac{+8}{3}\right) \quad \frac{+9}{3}$

$d(\downarrow, \mathrm{R}), d(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-7}{3}, \frac{-4}{3}, \frac{-1}{3}\right) \quad \frac{-12}{3}$

$u(\uparrow, \mathrm{R}), d(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{-4}{3}, \frac{-1}{3}\right) \quad \frac{-6}{3}$

$u(\uparrow, \mathrm{R}), u(\uparrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{+2}{3}, \frac{-1}{3}\right) \quad \frac{0}{3}$

$d(\downarrow, \mathrm{R}), s(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-7}{3}, \frac{-7}{3}, \frac{-1}{3}\right) \quad \frac{-15}{3}$

$u(\uparrow, \mathrm{R}), s(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-1}{3}, \frac{-7}{3}, \frac{-1}{3}\right) \quad \frac{-9}{3}$

$s(\downarrow, \mathrm{R}), s(\downarrow, \mathrm{G}), s(\downarrow, \mathrm{B})$
$\left(\frac{-10}{3}, \frac{-7}{3}, \frac{-1}{3}\right) \quad \frac{-18}{3}$

Figue 2: Spin-Color States $\{q(\chi, \alpha), \bar{q}(\chi, \beta), q(\chi, \gamma)\}$ of charmed corored baryon $qqq + qqq_{\text{color}}$ SU(4)

Further, obtain

$$S_3(ccc)\,\tfrac{+6}{3}$$

$$S_3(ccd)\,\tfrac{+3}{3} \qquad S_3(ccu)\,\tfrac{+5}{3}$$

$$S_3(ccs)\,\tfrac{+2}{3}$$

$$S_3(qqq, qqq_{\text{color}}) \equiv S_3(\text{qqq}) = \quad S_3(cdd)\,\tfrac{0}{3} \qquad S_3(cud)\,\tfrac{+2}{3} \qquad S_3(cuu)\,\tfrac{+4}{3}$$

$$S_3(cds)\,\tfrac{-1}{3} \qquad S_3(cus)\,\tfrac{+1}{3}$$

$$S_3(css)\,\tfrac{-2}{3}$$

$$S_3(ddd)\,\tfrac{-3}{3} \qquad S_3(udd)\,\tfrac{-1}{3} \qquad S_3(uud)\,\tfrac{+1}{3} \qquad S_3(uuu)\,\tfrac{+3}{3}$$

$$S_3(dds)\,\tfrac{-4}{3} \qquad S_3(uds)\,\tfrac{-2}{3} \qquad S_3(uus)\,\tfrac{0}{3}$$

$$S_3(dss)\,\tfrac{-5}{3} \qquad S_3(uss)\,\tfrac{-3}{3}$$

$$S_3(sss)\,\tfrac{-6}{3}$$

Figure 3: Weight diagram of $S_3(qqq, qqq_{\text{color}})^*$ of spin-color state for charmed colored baryon SU(4)

【***Emphasis***】 Figure.3 shows spin (the third components) of charmed colored quark SU(4) possess one-third series fraction property.

Global Journal of Science Frontier Research (A) Volume XXIII Issue II Version I Year 2023

Part.B Gluon

Obviously, both colored quarks (in Table.2) and colored baryons (in Figure.2), which are colored particles, are unobservable On the contrary, observed baryons are observable which are colorless. To coordinate the conflict, we are back to reunderstand the early original quark model [1]. We see: this model does not include any interaction among quarks, or any interaction between quark and antiquark. That is to say, the model only comprises quark particles, in fact, it is a static one. So seems to be necessary of adding some other particles that posess decolorant function, further absorb and balance the color conflict mentioned before.

The first and better cadinate is gluon g, of cause, the gluon should be colorful too. So we turn to the cadidates ggg and ggg_{color}, here ggg is spin angular momentum of gluon g and ggg_{color} is its color. In order to overcome the confliction with spin one-third series fraction property of colored baryons, ggg and ggg_{color} should be assiciated with relevant qqq and qqq_{color} and should also possess a similar arrays of three components of qqq and qqq_{color} (mare detailed figures about ggg and ggg_{color} would be presented later, Part.C section 8)

4. Approaching to Observable Experimental Baryons

qqq, qqq_{color} and ggg, ggg_{color} are important roles, from which observable experimental baryons could be formed in STS. To approaching to the purpose, two equivalent calculation methods, 【1】and【2】are given by following Table.3. (And Figure.3 $S_3(qqq, qqq_{\text{color}})^*$ is a part of【1】)

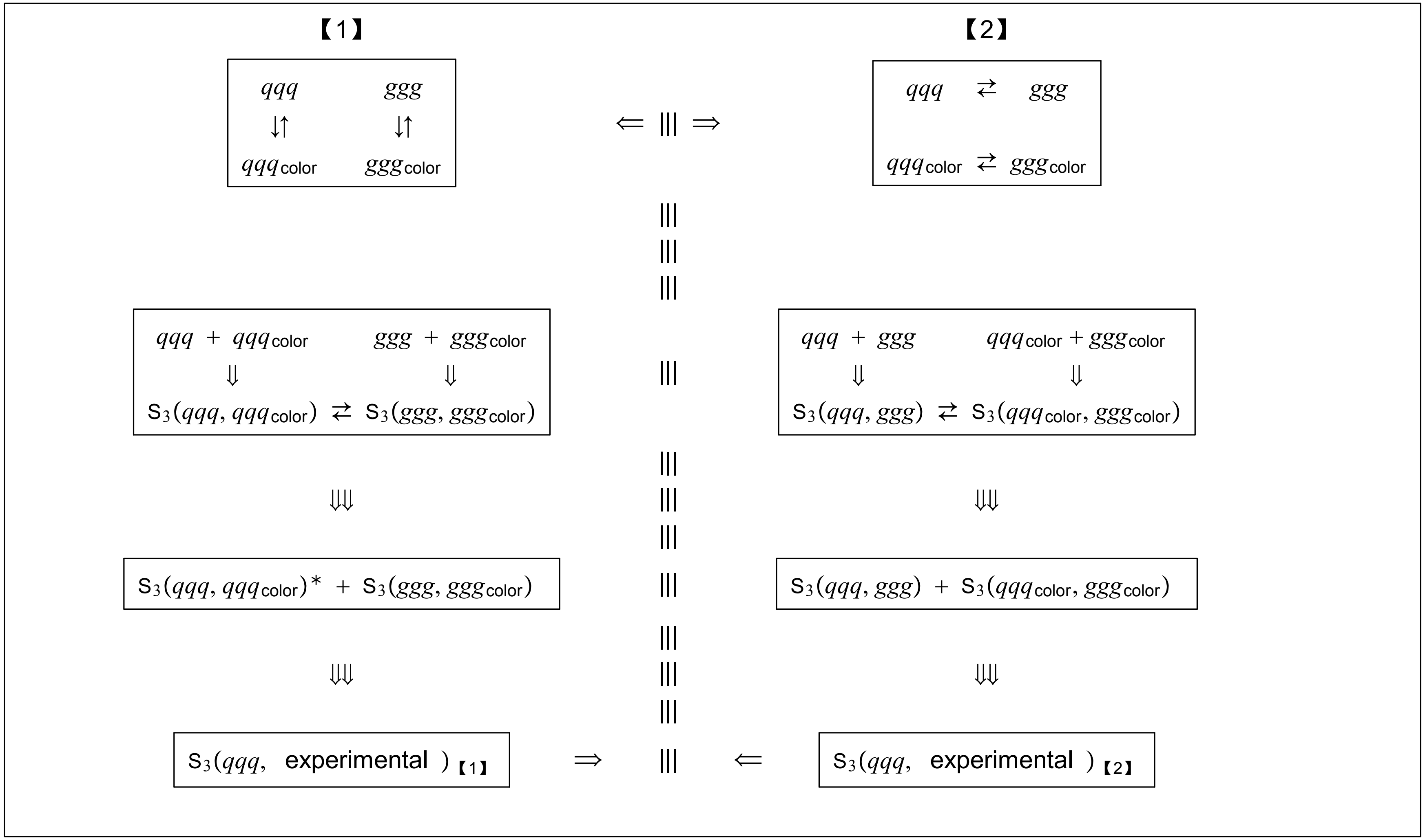

Table 3: Two equivalent calculation methods of approaching to observable experimental baryons

To find out the concrete presentations of ggg and ggg_{color} in above table, preliminary researches on gluon are given following

【Preliminary on 5. , 6. , and 7.】

5. COLORED GLUON $g(\alpha\overline{\beta})$

Go without saying, analogy to *colored quark* mentioned (section **2.***) , *colored gluon* is defined as

colored gluon: $$g(\alpha\overline{\beta}) = g + g_{\alpha\overline{\beta}} \quad (6)$$

which is the algebra sum (6) of colorless *gulon spin* g and *gluon corlor* $g_{\alpha\overline{\beta}}$

$$g_{\alpha\overline{\beta}} = g_{\alpha\overline{\beta}}(q_\alpha, \overline{q}_\beta) = q_\alpha + \overline{q}_\beta \quad (7)$$

Where symbol g is the third component of spin angular momentum of gluon, and *gluon corlor* $g_{\alpha\overline{\beta}}$ is color of force-mediating gluon, which between two interacting quarks q and antiquark $\overline{q}$. (6) shows colorless spin 1 gluon becomes colorful gluon being colored by gluon color $g_{\alpha\overline{\beta}}$,

As examples of (7) of gluon color $g_{\alpha\overline{\beta}}$ which results from quark-antiquark pair $(u,\overline{u})$ and pair $(u,\overline{d})$.

$$g_{\mathrm{R\overline{R}}}(u,\overline{u}) = u_{\mathrm{R}} + \overline{u}_{\mathrm{\overline{R}}} = \frac{-5}{6} + \frac{+5}{6} = \frac{0}{6} = 0 \quad (7.1)$$

$$g_{\mathrm{R\overline{G}}}(u,\overline{u}) = u_{\mathrm{R}} + \overline{u}_{\mathrm{\overline{G}}} = \frac{-5}{6} + \frac{-1}{6} = \frac{-6}{6} = -1 \quad (7.2)$$

$$g_{\mathrm{R\overline{B}}}(u,\overline{u}) = u_{\mathrm{R}} + \overline{u}_{\mathrm{\overline{B}}} = \frac{-5}{6} + \frac{-13}{6} = \frac{-18}{6} = -3 \quad (7.3)$$

$$g_{\mathrm{R\overline{R}}}(u,\overline{d}) = u_{\mathrm{R}} + \overline{d}_{\mathrm{\overline{R}}} = \frac{-5}{6} + \frac{+11}{6} = \frac{+6}{6} = +1 \quad (7.4)$$

$$g_{\mathrm{G\overline{G}}}(u,\overline{d}) = u_{\mathrm{G}} + \overline{d}_{\mathrm{\overline{G}}} = \frac{+1}{6} + \frac{+5}{6} = \frac{+6}{6} = +1 \quad (7.5)$$

$$g_{\mathrm{B\overline{B}}}(u,\overline{d}) = u_{\mathrm{B}} + \overline{d}_{\mathrm{\overline{B}}} = \frac{+13}{6} + \frac{-7}{6} = \frac{+6}{6} = +1 \quad (7.6)$$

we see: the values of gluon color $g_{\alpha\overline{\beta}}$ possesses zero and integral number properties.

【*Emphasis*】 both values of *quark corlor* q_α, q_β and values of *gluon corlor* $g_{\alpha\overline{\beta}}$ all come from CSDF, Fundamental Color Representation of flavor (Table.1)

6. Gluon Corlor $g_{\alpha\overline{\beta}}$

Gluon corlor $g_{\alpha\beta}$ is Color-Flavor Antisymmetric Matrix, CFAM,

$$g_{\alpha\bar{\beta}}(r, \overline{\omega}) + g_{\beta\bar{\alpha}}(w, \bar{r}) = 0 \tag{8}$$

with respective to:

color transformation $\alpha \Leftrightarrow \beta$ (8.1)

flavor transformation $r \Leftrightarrow \omega$ (8.2)

As examples of (8) below

$$g_{\mathrm{R}\bar{\mathrm{G}}}(u,\bar{u}) = u_{\mathrm{R}} + \bar{u}_{\bar{\mathrm{G}}} = \frac{-5}{6} + \frac{-1}{6} = \frac{-6}{6} = -1 \tag{8.3}$$

$$g_{\mathrm{G}\bar{\mathrm{R}}}(u,\bar{u}) = u_{\mathrm{G}} + \bar{u}_{\bar{\mathrm{R}}} = \frac{+1}{6} + \frac{+5}{6} = \frac{+6}{6} = +1 \tag{8.4}$$

and

$$g_{\mathrm{R}\bar{\mathrm{G}}}(u,\bar{u}) + g_{\mathrm{G}\bar{\mathrm{R}}}(u,\bar{u}) = 0 \tag{8.5}$$

$$g_{\mathrm{R}\bar{\mathrm{G}}}(d,\bar{u}) = d_{\mathrm{R}} + \bar{u}_{\bar{\mathrm{G}}} = \frac{-11}{6} + \frac{-1}{6} = \frac{-12}{6} = -2 \tag{8.6}$$

$$g_{\mathrm{G}\bar{\mathrm{R}}}(u,\bar{d}) = u_{\mathrm{G}} + \bar{d}_{\bar{\mathrm{R}}} = \frac{+1}{6} + \frac{+11}{6} = \frac{+12}{6} = +2 \tag{8.7}$$

and

$$g_{\mathrm{R}\bar{\mathrm{G}}}(d, \bar{u}) + g_{\mathrm{G}\bar{\mathrm{R}}}(u, \bar{d}) = 0 \tag{8.8}$$

In this way, concrete details of *Gluon corlor* $g_{\alpha\beta}$ is given by Table.4 below, that includes eighteen matrices which are arranged in color-flavor Aantisymmetric matrix $(r, \overline{w})$.

Following

1) $r = w$, $g_{\alpha\bar{\beta}}(r,\bar{r})$ former six matrices, $(u, \bar{u})$,$(d, \bar{d})$,$(s, \bar{s})$,$(c, \bar{c})$,$(b, \bar{b})$,$(t, \bar{t})$ belong to diagonal figures;

2) $r \neq w$, $g_{\alpha\bar{\beta}}(r,\overline{w})$ latter twelve matrices $\{(u, \bar{d}),(d, \bar{u})\}$, $\{(u, \bar{s}),(s, \bar{u})\}$, $\{(c, \bar{d}),(d, \bar{c})\}$,... to off-diagonal figures

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Table 4: Gluon Corlor $g_{\alpha\overline{\beta}}(r,\overline{w})$ $r, w = t, c, u, d, s, b$

$g_{\alpha\overline{\beta}}(r,\overline{w})$ $r_\alpha + \overline{w}_{\overline{\beta}}$	$\overline{\omega}$	$\overline{w}_{\overline{R}}$ $\frac{-a}{6}$	$\overline{w}_{\overline{G}}$ $\frac{-b}{6}$	$\overline{w}_{\overline{B}}$ $\frac{-c}{6}$
r	$(r,\overline{w})$			
r_R $\frac{+a}{6}$		$g_{R\overline{R}}$ 0	$g_{R\overline{G}}$ -1	$g_{R\overline{B}}$ -3
r_G $\frac{+b}{6}$		$g_{G\overline{R}}$ $+1$	$g_{G\overline{G}}$ 0	$g_{G\overline{B}}$ -2
r_B $\frac{+c}{6}$		$g_{B\overline{R}}$ $+3$	$g_{B\overline{G}}$ $+2$	$g_{B\overline{B}}$ 0

$r = w$

Here concise symbol $(r,\overline{w})$ is a matrix element of CFAM $g_{\alpha\overline{\beta}}(r_\alpha, \overline{w}_{\overline{\beta}})$ that related to quark r and antiquark $\overline{w}$. And $(r,\overline{w}) \in g_{\alpha\overline{\beta}}(q_\alpha, \overline{q}_{\overline{\beta}})$

More detailed following

$g_{\alpha\bar\beta}(t,\bar t)$ $t_\alpha+\bar t_\beta$	ϖ	$\bar t_R$ $\frac{-7}{6}$	$\bar t_G$ $\frac{-13}{6}$	$\bar t_B$ $\frac{-25}{6}$
r	$(t,\bar t)$			
t_R $\frac{+7}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
t_G $\frac{+13}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
t_B $\frac{+25}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$g_{\alpha\bar\beta}(c,\bar c)$ $c_\alpha+\bar c_\beta$	ϖ	$\bar c_R$ $\frac{-1}{6}$	$\bar c_G$ $\frac{-7}{6}$	$\bar c_B$ $\frac{-19}{6}$
r	$(c,\bar c)$			
c_R $\frac{+1}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
c_G $\frac{+7}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
c_B $\frac{+19}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$g_{\alpha\bar\beta}(u,\bar u)$ $u_\alpha+\bar u_\beta$	ϖ	$\bar u_R$ $\frac{+5}{6}$	$\bar u_G$ $\frac{-1}{6}$	$\bar u_B$ $\frac{-13}{6}$
r	$(u,\bar u)$			
u_R $\frac{-5}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
u_G $\frac{+1}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
u_B $\frac{+13}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$g_{\alpha\bar\beta}(b,\bar b)$ $b_\alpha+\bar b_\beta$	ϖ	$\bar b_R$ $\frac{+23}{6}$	$\bar b_G$ $\frac{+17}{6}$	$\bar b_B$ $\frac{+5}{6}$
r	$(b,\bar b)$			
b_R $\frac{-23}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
b_G $\frac{-17}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
b_B $\frac{-5}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$g_{\alpha\bar\beta}(s,\bar s)$ $s_\alpha+\bar s_\beta$	ϖ	$\bar s_R$ $\frac{+17}{6}$	$\bar s_G$ $\frac{+11}{6}$	$\bar s_B$ $\frac{-1}{6}$
r	$(s,\bar s)$			
s_R $\frac{-17}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
s_G $\frac{-11}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
s_B $\frac{+1}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$g_{\alpha\bar\beta}(d,\bar d)$ $d_\alpha+\bar d_\beta$	ϖ	$\bar d_R$ $\frac{+11}{6}$	$\bar d_G$ $\frac{+5}{6}$	$\bar d_B$ $\frac{-7}{6}$
r	$(d,\bar d)$			
d_R $\frac{-11}{6}$		$g_{R\bar R}$ 0	$g_{R\bar G}$ −1	$g_{R\bar B}$ −3
d_G $\frac{-5}{6}$		$g_{G\bar R}$ +1	$g_{G\bar G}$ 0	$g_{G\bar B}$ −2
d_B $\frac{+7}{6}$		$g_{B\bar R}$ +3	$g_{B\bar G}$ +2	$g_{B\bar B}$ 0

$(u,\bar{d})$	$\frac{+11}{6}$	$\frac{+5}{6}$	$\frac{-7}{6}$	$(d,\bar{u})$	$\frac{+5}{6}$	$\frac{-1}{6}$	$\frac{-13}{6}$
$\frac{-5}{6}$	$g_{R\bar{R}}$ $+1$	$g_{R\bar{G}}$ 0	$g_{R\bar{B}}$ -2	$\frac{-11}{6}$	$g_{R\bar{R}}$ -1	$g_{R\bar{G}}$ -2	$g_{R\bar{B}}$ -4
$\frac{+1}{6}$	$g_{G\bar{R}}$ $+2$	$g_{G\bar{G}}$ $+1$	$g_{G\bar{B}}$ -1	$\frac{-5}{6}$	$g_{G\bar{R}}$ 0	$g_{G\bar{G}}$ -1	$g_{G\bar{B}}$ -3
$\frac{+13}{6}$	$g_{B\bar{R}}$ $+4$	$g_{B\bar{G}}$ $+3$	$g_{B\bar{B}}$ $+1$	$\frac{+7}{6}$	$g_{B\bar{R}}$ $+2$	$g_{B\bar{G}}$ $+1$	$g_{B\bar{B}}$ -1

$(u,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{u})$	$\frac{+5}{6}$	$\frac{-1}{6}$	$\frac{-13}{6}$
$\frac{-5}{6}$	$g_{R\bar{R}}$ $+2$	$g_{R\bar{G}}$ $+1$	$g_{R\bar{B}}$ -1	$\frac{-17}{6}$	$g_{R\bar{R}}$ -2	$g_{R\bar{G}}$ -3	$g_{R\bar{B}}$ -5
$\frac{+1}{6}$	$g_{G\bar{R}}$ $+3$	$g_{G\bar{G}}$ $+2$	$g_{G\bar{B}}$ 0	$\frac{-11}{6}$	$g_{G\bar{R}}$ -1	$g_{G\bar{G}}$ -2	$g_{G\bar{B}}$ -4
$\frac{+13}{6}$	$g_{B\bar{R}}$ $+5$	$g_{B\bar{G}}$ $+4$	$g_{B\bar{B}}$ $+2$	$\frac{+1}{6}$	$g_{B\bar{R}}$ $+1$	$g_{B\bar{G}}$ 0	$g_{B\bar{B}}$ -2

$(c,\bar{d})$	$\frac{+11}{6}$	$\frac{+5}{6}$	$\frac{-7}{6}$	$(d,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ $+2$	$g_{R\bar{G}}$ $+1$	$g_{R\bar{B}}$ -1	$\frac{-11}{6}$	$g_{R\bar{R}}$ -2	$g_{R\bar{G}}$ -3	$g_{R\bar{B}}$ -5
$\frac{+7}{6}$	$g_{G\bar{R}}$ $+3$	$g_{G\bar{G}}$ $+2$	$g_{G\bar{B}}$ 0	$\frac{-5}{6}$	$g_{G\bar{R}}$ -1	$g_{G\bar{G}}$ -2	$g_{G\bar{B}}$ -4
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+5$	$g_{B\bar{G}}$ $+4$	$g_{B\bar{B}}$ $+2$	$\frac{+7}{6}$	$g_{B\bar{R}}$ $+1$	$g_{B\bar{G}}$ 0	$g_{B\bar{B}}$ -2

$(c,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ $+3$	$g_{R\bar{G}}$ $+2$	$g_{R\bar{B}}$ 0	$\frac{-17}{6}$	$g_{R\bar{R}}$ -3	$g_{R\bar{G}}$ -4	$g_{R\bar{B}}$ -6
$\frac{+7}{6}$	$g_{G\bar{R}}$ $+4$	$g_{G\bar{G}}$ $+3$	$g_{G\bar{B}}$ $+1$	$\frac{-11}{6}$	$g_{G\bar{R}}$ -2	$g_{G\bar{G}}$ -3	$g_{G\bar{B}}$ -5
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+6$	$g_{B\bar{G}}$ $+5$	$g_{B\bar{B}}$ $+3$	$\frac{+1}{6}$	$g_{B\bar{R}}$ 0	$g_{B\bar{G}}$ -1	$g_{B\bar{B}}$ -3

$(c,\bar{u})$	$\frac{+5}{6}$	$\frac{-1}{6}$	$\frac{-13}{6}$	$(u,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ $+1$	$g_{R\bar{G}}$ 0	$g_{R\bar{B}}$ -2	$\frac{-5}{6}$	$g_{R\bar{R}}$ -1	$g_{R\bar{G}}$ -2	$g_{R\bar{B}}$ -4
$\frac{+7}{6}$	$g_{G\bar{R}}$ $+2$	$g_{G\bar{G}}$ $+1$	$g_{G\bar{B}}$ -1	$\frac{+1}{6}$	$g_{G\bar{R}}$ 0	$g_{G\bar{G}}$ -1	$g_{G\bar{B}}$ -3
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+4$	$g_{B\bar{G}}$ $+3$	$g_{B\bar{B}}$ $+1$	$\frac{+13}{6}$	$g_{B\bar{R}}$ $+2$	$g_{B\bar{G}}$ $+1$	$g_{B\bar{B}}$ -1

$(d,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{d})$	$\frac{+11}{6}$	$\frac{+5}{6}$	$\frac{-7}{6}$
$\frac{-11}{6}$	$g_{R\bar{R}}$ $+1$	$g_{R\bar{G}}$ 0	$g_{R\bar{B}}$ -2	$\frac{-17}{6}$	$g_{R\bar{R}}$ -1	$g_{R\bar{G}}$ -2	$g_{R\bar{B}}$ -4
$\frac{-5}{6}$	$g_{G\bar{R}}$ $+2$	$g_{G\bar{G}}$ $+1$	$g_{G\bar{B}}$ -1	$\frac{-11}{6}$	$g_{G\bar{R}}$ 0	$g_{G\bar{G}}$ -1	$g_{G\bar{B}}$ -3
$\frac{+7}{6}$	$g_{B\bar{R}}$ $+4$	$g_{B\bar{G}}$ $+3$	$g_{B\bar{B}}$ $+1$	$\frac{+1}{6}$	$g_{B\bar{R}}$ $+2$	$g_{B\bar{G}}$ $+1$	$g_{B\bar{B}}$ -1

$(c,\bar{t})$	$\frac{-7}{6}$	$\frac{-13}{6}$	$\frac{-25}{6}$	$(t,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ -1	$g_{R\bar{G}}$ -2	$g_{R\bar{B}}$ -4	$\frac{+7}{6}$	$g_{R\bar{R}}$ $+1$	$g_{R\bar{G}}$ 0	$g_{R\bar{B}}$ -2
$\frac{+7}{6}$	$g_{G\bar{R}}$ 0	$g_{G\bar{G}}$ -1	$g_{G\bar{B}}$ -3	$\frac{+13}{6}$	$g_{G\bar{R}}$ $+2$	$g_{G\bar{G}}$ $+1$	$g_{G\bar{B}}$ -1
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+2$	$g_{B\bar{G}}$ $+1$	$g_{B\bar{B}}$ -1	$\frac{+25}{6}$	$g_{B\bar{R}}$ $+4$	$g_{B\bar{G}}$ $+3$	$g_{B\bar{B}}$ $+1$

$(t,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{t})$	$\frac{-7}{6}$	$\frac{-13}{6}$	$\frac{-25}{6}$
$\frac{+7}{6}$	$g_{R\bar{R}}$ $+4$	$g_{R\bar{G}}$ $+3$	$g_{R\bar{B}}$ $+1$	$\frac{-17}{6}$	$g_{R\bar{R}}$ -4	$g_{R\bar{G}}$ -5	$g_{R\bar{B}}$ -7
$\frac{+13}{6}$	$g_{G\bar{R}}$ $+5$	$g_{G\bar{G}}$ $+4$	$g_{G\bar{B}}$ $+2$	$\frac{-11}{6}$	$g_{G\bar{R}}$ -3	$g_{G\bar{G}}$ -4	$g_{G\bar{B}}$ -6
$\frac{+25}{6}$	$g_{B\bar{R}}$ $+7$	$g_{B\bar{G}}$ $+6$	$g_{B\bar{B}}$ $+4$	$\frac{+1}{6}$	$g_{B\bar{R}}$ -1	$g_{B\bar{G}}$ -2	$g_{B\bar{B}}$ -4

$(c,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ $+3$	$g_{R\bar{G}}$ $+2$	$g_{R\bar{B}}$ 0	$\frac{-17}{6}$	$g_{R\bar{R}}$ -3	$g_{R\bar{G}}$ -4	$g_{R\bar{B}}$ -6
$\frac{+7}{6}$	$g_{G\bar{R}}$ $+4$	$g_{G\bar{G}}$ $+3$	$g_{G\bar{B}}$ $+1$	$\frac{-11}{6}$	$g_{G\bar{R}}$ -2	$g_{G\bar{G}}$ -3	$g_{G\bar{B}}$ -5
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+6$	$g_{B\bar{G}}$ $+5$	$g_{B\bar{B}}$ $+3$	$\frac{+1}{6}$	$g_{B\bar{R}}$ 0	$g_{B\bar{G}}$ -1	$g_{B\bar{B}}$ -3

$(t,\bar{b})$	$\frac{+23}{6}$	$\frac{+17}{6}$	$\frac{+5}{6}$	$(b,\bar{t})$	$\frac{-7}{6}$	$\frac{-13}{6}$	$\frac{-25}{6}$
$\frac{+7}{6}$	$g_{R\bar{R}}$ $+5$	$g_{R\bar{G}}$ $+4$	$g_{R\bar{B}}$ $+2$	$\frac{-23}{6}$	$g_{R\bar{R}}$ -5	$g_{R\bar{G}}$ -6	$g_{R\bar{B}}$ -8
$\frac{+13}{6}$	$g_{G\bar{R}}$ $+6$	$g_{G\bar{G}}$ $+5$	$g_{G\bar{B}}$ $+3$	$\frac{-17}{6}$	$g_{G\bar{R}}$ -4	$g_{G\bar{G}}$ -5	$g_{G\bar{B}}$ -7
$\frac{+25}{6}$	$g_{B\bar{R}}$ $+8$	$g_{B\bar{G}}$ $+7$	$g_{B\bar{B}}$ $+5$	$\frac{-5}{6}$	$g_{B\bar{R}}$ -2	$g_{B\bar{G}}$ -3	$g_{B\bar{B}}$ -5

$(c,\bar{b})$	$\frac{+23}{6}$	$\frac{+17}{6}$	$\frac{+5}{6}$	$(b,\bar{c})$	$\frac{-1}{6}$	$\frac{-7}{6}$	$\frac{-19}{6}$
$\frac{+1}{6}$	$g_{R\bar{R}}$ $+4$	$g_{R\bar{G}}$ $+3$	$g_{R\bar{B}}$ $+1$	$\frac{-23}{6}$	$g_{R\bar{R}}$ -4	$g_{R\bar{G}}$ -5	$g_{R\bar{B}}$ -7
$\frac{+7}{6}$	$g_{G\bar{R}}$ $+5$	$g_{G\bar{G}}$ $+4$	$g_{G\bar{B}}$ $+2$	$\frac{-17}{6}$	$g_{G\bar{R}}$ -3	$g_{G\bar{G}}$ -4	$g_{G\bar{B}}$ -6
$\frac{+19}{6}$	$g_{B\bar{R}}$ $+7$	$g_{B\bar{G}}$ $+6$	$g_{B\bar{B}}$ $+4$	$\frac{-5}{6}$	$g_{B\bar{R}}$ -1	$g_{B\bar{G}}$ -2	$g_{B\bar{B}}$ -4

$(b,\bar{s})$	$\frac{+17}{6}$	$\frac{+11}{6}$	$\frac{-1}{6}$	$(s,\bar{b})$	$\frac{+23}{6}$	$\frac{+17}{6}$	$\frac{+5}{6}$
$\frac{-23}{6}$	$g_{R\bar{R}}$ -1	$g_{R\bar{G}}$ -2	$g_{R\bar{B}}$ -4	$\frac{-17}{6}$	$g_{R\bar{R}}$ $+1$	$g_{R\bar{G}}$ 0	$g_{R\bar{B}}$ -2
$\frac{-17}{6}$	$g_{G\bar{R}}$ 0	$g_{G\bar{G}}$ -1	$g_{G\bar{B}}$ -3	$\frac{-11}{6}$	$g_{G\bar{R}}$ $+2$	$g_{G\bar{G}}$ $+1$	$g_{G\bar{B}}$ -1
$\frac{-5}{6}$	$g_{B\bar{R}}$ $+2$	$g_{B\bar{G}}$ $+1$	$g_{B\bar{B}}$ -1	$\frac{+1}{6}$	$g_{B\bar{R}}$ $+4$	$g_{B\bar{G}}$ $+3$	$g_{B\bar{B}}$ $+1$

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7. Gluon Corlor Matrix, $\alpha\overline{\beta}$ ($r\overline{w}$) or αβM

We could rewrite Table.4 *Gluon corlor* $g_{\alpha\beta}$ into Table.5 *Gluon Corlor Matrix,* $\alpha\beta M$ below. And use label $\alpha\overline{\beta}(r\overline{\varpi})$ instead of $g_{\alpha\beta}(r,\overline{\varpi})$, then antisymmetric relation, (8.5) and (8.8) are rewritten as

$$\mathrm{R\overline{G}}(u\overline{u}) + \mathrm{G\overline{R}}(u\overline{u}) = 0 \tag{8.9}$$

$$\mathrm{R\overline{G}}(d\overline{u}) + \mathrm{G\overline{R}}(u\overline{d}) = 0 \tag{8.10}$$

$\alpha\beta M$ include nine subtables, among them: three are color diagonal $1,2,3$ subtables with $\alpha\overline{\beta} = \mathrm{R\overline{R}, G\overline{G}, B\overline{B}}$ and six color off-diagonal $4,6,8,$ subtables with $\alpha\overline{\beta} = \mathrm{R\overline{G}, G\overline{B}, B\overline{R}}$ and $5,7,9$ subtables with $\beta\overline{\alpha} = \mathrm{G\overline{R}, B\overline{G}, R\overline{B}}$.

In next two sections, **C** and **D**, we will use $\alpha\beta M$ to construct gulon color $ggg_{\text{color}}(qqq)$ and $g\overline{g}_{\text{color}}(q\overline{q})$.

Table 5: **Gluon Corlor Matrix,** $\alpha\beta M$ is expressed following:

color diagonal $\alpha = \beta$ $\alpha\overline{\beta}(r\overline{\varpi})=\beta\overline{\alpha}(r\overline{\varpi})$: α=R $\mathrm{R\overline{R}}(r\overline{\varpi})$, α=G $\mathrm{G\overline{G}}(r\overline{\varpi})$, α=B $\mathrm{B\overline{B}}(r\overline{\varpi})$

1	$\overline{\mathrm{R}}$	ϖ	$\overline{t}$	$\overline{c}$	$\overline{u}$	$\overline{d}$	$\overline{s}$	$\overline{b}$
R			$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$	$\frac{+23}{6}$
r		$\mathrm{R\overline{R}}$						
t	$\frac{+7}{6}$		0	+1	+2	+3	+4	+5
c	$\frac{+1}{6}$		−1	0	+1	+2	+3	+4
u	$\frac{-5}{6}$		−2	−1	0	+1	+2	+3
d	$\frac{-11}{6}$		−3	−2	−1	0	+1	+2
s	$\frac{-17}{6}$		−4	−3	−2	−1	0	+1
b	$\frac{-23}{6}$		−5	−4	−3	−2	−1	0

$\mathrm{R\overline{R}}(r\overline{\varpi})$

2	$\overline{\mathrm{G}}$	ϖ	$\overline{t}$	$\overline{c}$	$\overline{u}$	$\overline{d}$	$\overline{s}$	$\overline{b}$
G			$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$
r		$\mathrm{G\overline{G}}$						
t	$\frac{+13}{6}$		0	+1	+2	+3	+4	+5
c	$\frac{+7}{6}$		−1	0	+1	+2	+3	+4
u	$\frac{+1}{6}$		−2	−1	0	+1	+2	+3
d	$\frac{-5}{6}$		−3	−2	−1	0	+1	+2
s	$\frac{-11}{6}$		−4	−3	−2	−1	0	+1
b	$\frac{-17}{6}$		−5	−4	−3	−2	−1	0

$\mathrm{G\overline{G}}(r\overline{\varpi})$

3	$\overline{\mathrm{B}}$	ϖ	$\overline{t}$	$\overline{c}$	$\overline{u}$	$\overline{d}$	$\overline{s}$	$\overline{b}$
B			$\frac{-25}{6}$	$\frac{-19}{6}$	$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$
r		$\mathrm{B\overline{B}}$						
t	$\frac{+25}{6}$		0	+1	+2	+3	+4	+5
c	$\frac{+19}{6}$		−1	0	+1	+2	+3	+4
u	$\frac{+13}{6}$		−2	−1	0	+1	+2	+3
d	$\frac{+7}{6}$		−3	−2	−1	0	+1	+2
s	$\frac{+1}{6}$		−4	−3	−2	−1	0	+1
b	$\frac{-5}{6}$		−5	−4	−3	−2	−1	0

$\mathrm{B\overline{B}}(r\overline{\varpi})$

color off-diagonal $\alpha \neq \beta$ $\alpha\overline{\beta}(r\overline{\varpi})$: $\mathrm{R\overline{G}}(r\overline{\varpi})$, $\mathrm{G\overline{B}}(r\overline{\varpi})$, $\mathrm{B\overline{R}}(\ \overline{\varpi})_r$

4	$\overline{\mathrm{G}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
R			$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$
r		$\mathrm{R\overline{G}}$						
t	$\frac{+7}{6}$		−1	0	+1	+2	+3	+4
c	$\frac{+1}{6}$		−2	−1	0	+1	+2	+3
u	$\frac{-5}{6}$		−3	−2	−1	0	+1	+2
d	$\frac{-11}{6}$		−4	−3	−2	−1	0	+1
s	$\frac{-17}{6}$		−5	−4	−3	−2	−1	0
b	$\frac{-23}{6}$		−6	−5	−4	−3	−2	−1

$\mathrm{R\overline{G}}(r\overline{\varpi})$

6	$\overline{\mathrm{B}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
G			$\frac{-25}{6}$	$\frac{-19}{6}$	$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$
r		$\mathrm{G\overline{B}}$						
t	$\frac{+13}{6}$		−2	−1	0	+1	+2	+3
c	$\frac{+7}{6}$		−3	−2	−1	0	+1	+2
u	$\frac{+1}{6}$		−4	−3	−2	−1	0	+1
d	$\frac{-5}{6}$		−5	−4	−3	−2	−1	0
s	$\frac{-11}{6}$		−6	−5	−4	−3	−2	−1
b	$\frac{-17}{6}$		−7	−6	−5	−4	−3	−2

$\mathrm{G\overline{B}}(r\overline{\varpi})$

8	$\overline{\mathrm{R}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
B			$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$	$\frac{+23}{6}$
r		$\mathrm{B\overline{R}}$						
t	$\frac{+25}{6}$		+3	+4	+5	+6	+7	+8
c	$\frac{+19}{6}$		+2	+3	+4	+5	+6	+7
u	$\frac{+13}{6}$		+1	+2	+3	+4	+5	+6
d	$\frac{+7}{6}$		0	+1	+2	+3	+4	+5
s	$\frac{+1}{6}$		−1	0	+1	+2	+3	+4
b	$\frac{-5}{6}$		−2	−1	0	+1	+2	+3

$\mathrm{B\overline{R}}(r\overline{\varpi})$

color off-diagonal $\alpha \neq \beta$ $\beta\overline{\alpha}(\omega\bar{r})$: $\mathrm{G\overline{R}}(\omega\bar{r})$, $\mathrm{B\overline{G}}(\omega\bar{r})$, $\mathrm{R\overline{B}}(\omega\bar{r})$

5	$\overline{\mathrm{R}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
G			$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$	$\frac{+23}{6}$
r		$\mathrm{G\overline{R}}$						
t	$\frac{+13}{6}$		+1	+2	+3	+4	+5	+6
c	$\frac{+7}{6}$		0	+1	+2	+3	+4	+5
u	$\frac{+1}{6}$		−1	0	+1	+2	+3	+4
d	$\frac{-5}{6}$		−2	−1	0	+1	+2	+3
s	$\frac{-11}{6}$		−3	−2	−1	0	+1	+2
b	$\frac{-17}{6}$		−4	−3	−2	−1	0	+1

$\mathrm{G\overline{R}}(\omega\bar{r})$

7	$\overline{\mathrm{G}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
B			$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$	$\frac{+11}{6}$	$\frac{+17}{6}$
r		$\mathrm{B\overline{G}}$						
t	$\frac{+25}{6}$		+2	+3	+4	+5	+6	+7
c	$\frac{+19}{6}$		+1	+2	+3	+4	+5	+6
u	$\frac{+13}{6}$		0	+1	+2	+3	+4	+5
d	$\frac{+7}{6}$		−1	0	+1	+2	+3	+4
s	$\frac{+1}{6}$		−2	−1	0	+1	+2	+3
b	$\frac{-5}{6}$		−3	−2	−1	0	+1	+2

$\mathrm{B\overline{G}}(\omega\bar{r})$

9	$\overline{\mathrm{B}}$	$\overline{\varpi}$	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
R			$\frac{-25}{6}$	$\frac{-19}{6}$	$\frac{-13}{6}$	$\frac{-7}{6}$	$\frac{-1}{6}$	$\frac{+5}{6}$
r		$\mathrm{R\overline{B}}$						
t	$\frac{+7}{6}$		−3	−2	−1	0	+1	+2
c	$\frac{+1}{6}$		−4	−3	−2	−1	0	+1
u	$\frac{-5}{6}$		−5	−4	−3	−2	−1	0
d	$\frac{-11}{6}$		−6	−5	−4	−3	−2	−1
s	$\frac{-17}{6}$		−7	−6	−5	−4	−3	−2
b	$\frac{-23}{6}$		−8	−7	−6	−5	−4	−3

$\mathrm{R\overline{B}}(\omega\bar{r})$

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Part.C Baryon Constituent Related to Gluon

8. Gluon Color ggg_{color} Associated with Baryon $ggg_{color}(qqq) = g(qqq)_{color}$

1) Gluon g is due to Boson, so its angular momentum spin ggg could be written as (l, m, n), $l, m, n \subseteq 0, \pm1, \pm2, \ldots$

2) Gluon color component ggg_{color}, the likeness of color $q^r_{\text{RGB}}=(q_{\text{R}}, q_{\text{G}}, q_{\text{B}})$ of flavor r, is an array that comprises three matrix elements respectely listed in subtables of Table.5 $\alpha\beta M$.

3) $ggg + ggg_{\text{color}}$ stands for colored gluon that related to baryon

♣ As example:

$$\begin{matrix} uds_{\text{color}} \\ (u_{\text{R}}, d_{\text{G}}, s_{\text{B}}) \\ \left(\frac{-5}{6}, \frac{-5}{6}, \frac{+1}{6}\right) \end{matrix} \Leftrightarrow (u_{\text{R}}, d_{\text{G}}, s_{\text{B}}) = uds_{\text{color}} = \left(\frac{-5}{6}, \frac{-5}{6}, \frac{+1}{6}\right) \tag{9.1}$$

$$\begin{matrix} ggg_{\text{color}} \\ ((u\bar{d}), (d\bar{s}), (s\bar{u})) \\ (\text{R}\bar{\text{R}}, \text{G}\bar{\text{B}}, \text{B}\bar{\text{G}}) \end{matrix} = \begin{matrix} ggg_{\text{color}} \\ (1, 6, 7) \\ (+1, -1, 0) \end{matrix} = \begin{matrix} ggg_{\text{color}} \\ ((u\bar{d})_{\text{R}\bar{\text{R}}}, (d\bar{s})_{\text{G}\bar{\text{B}}}, (s\bar{u})_{\text{B}\bar{\text{G}}}) \\ (+1, -1, 0) \end{matrix} \Leftrightarrow ((u\bar{d})_{\text{R}\bar{\text{R}}}, (d\bar{s})_{\text{G}\bar{\text{B}}}, (s\bar{u})_{\text{B}\bar{\text{G}}}) = ggg_{\text{color}} = (+1, -1, 0) \tag{9.2}$$

For special case below:

Definition corlor ground state of the gluon: $ggg_{\text{color}} = (0, 0, 0)$

abbrevation $g(qqq)_{\text{color}} \equiv ggg_{\text{color}}(qqq)$, while ggg_{color} associated with baryon qqq and ground state of $g(qqq;0)_{\text{color}} = (0, 0, 0)$

♣ As example of ggg_{color} associated with baryon uud. From subtables 3, 4 and 5 in Table.5 $\alpha\beta M$ we could get ground state of $g(uud;0)_{\text{color}}$ (9.3) that will be appear in Figure.4.2 below

$$\begin{matrix} g(uud;0)_{\text{color}} \\ ((u\bar{u}), (u\bar{d}), (d\bar{u})) \\ (\text{B}\bar{\text{B}}, \text{R}\bar{\text{G}}, \text{G}\bar{\text{R}}) \end{matrix} = \begin{matrix} g(uud;0)_{\text{color}} \\ (3, 4, 5) \\ (0, 0, 0) \end{matrix} \Leftrightarrow g(uud;0)_{\text{color}} = (0, 0, 0) \tag{9.3}$$

9. Corlor Ground State $g(qqq,0)_{color}$ = (0,0,0) of Gluon SU(4)

Corlor ground state $g(qqq;0)_{\text{color}}$ of Gluon SU(4), associated with baryon qqq, consist of four groups of gulon multiplets: Figure.4.1 includes gluon ground states for groups singlet, triplet, hexaplet and Figure.4.2 for group decuplet.

Remark all $g(qqq;0)_{\text{color}}$ of Figure.4.1 and Figure.4.2 are corlor ground state of gluon: *that is* $\begin{matrix} g(q_1q_2q_3;0)_{\text{color}} \\ ((q_1\bar{q}_2),(q_2\bar{q}_3),(q_3\bar{q}_1)) \\ (0,\ 0,\ 0) \end{matrix}$

Notation $g(uds;0)_{\text{color}}$, $g(cud;0)_{\text{color}}$

$$\begin{matrix} g(uds;0)_{\text{color}} \\ ((u\bar{d}),(d\bar{s}),(s\bar{u})) \\ (R\bar{R},\ G\bar{B},\ B\bar{G}) \end{matrix} + \begin{matrix} g(uds;0)_{\text{color}} \\ ((d\bar{u}),(s\bar{d}),(u\bar{s})) \\ (R\bar{R},\ B\bar{G},\ G\bar{B}) \end{matrix} = \begin{matrix} g(uds;0)_{\text{color}} \\ (1,\ 6,\ 7) \\ (+1,\ -1,\ 0) \end{matrix} + \begin{matrix} g(uds;0)_{\text{color}} \\ (1,\ 7,\ 6) \\ (-1,\ +1,\ 0) \end{matrix} \tag{10.1}$$

$$\begin{matrix} g(cud;0)_{\text{color}} \\ ((c\bar{u}),(u\bar{d}),(d\bar{c})) \\ (R\bar{G},\ B\bar{B},\ G\bar{R}) \end{matrix} + \begin{matrix} g(cud;0)_{\text{color}} \\ ((u\bar{c}),(d\bar{u}),(c\bar{d})) \\ (G\bar{R},\ B\bar{B},\ R\bar{G}) \end{matrix} = \begin{matrix} g(cud;0)_{\text{color}} \\ (4,\ 2,\ 5) \\ (0,\ +1,\ -1) \end{matrix} + \begin{matrix} g(cud;0)_{\text{color}} \\ (5,\ 3,\ 4) \\ (0,\ -1,\ +1) \end{matrix} \tag{10.2}$$

Then get

linear combination of (10.1) $\begin{matrix} g(uds;0)^{\text{linear combination}}_{\text{color}} \\ (0,\ 0,\ 0) \end{matrix} = \begin{matrix} \frac{1}{2}\{\ (R\bar{R}, G\bar{B}, B\bar{G}) + (R\bar{R}, B\bar{G}, G\bar{B})\ \} \\ \frac{1}{2}\{\ (+1,\ -1,\ 0) + (-1,\ +1,\ 0)\ \} \end{matrix}$ in decuplet gulon (10.3)

linear combination of (10.2) $\begin{matrix} g(cud;0)^{\text{linear combination}}_{\text{color}} \\ (0,\ 0,\ 0) \end{matrix} = \begin{matrix} \frac{1}{2}\{\ (R\bar{G}, B\bar{B}, G\bar{R}) + (G\bar{R}, B\bar{B}, R\bar{G})\ \} \\ \frac{1}{2}\{\ (0,\ +1,\ -1) + (0,\ -1,\ +1)\ \} \end{matrix}$ in hexaplet gulon (10.4) singlet gulon

$g(ccc;0)_{\text{color}}$

$((c\bar{c}),(c\bar{c}),(c\bar{c}))$

$(R\bar{R},\ G\bar{G},\ B\bar{B})$

triplet gulon

$g(ccd;0)_{\text{color}}$

$((c\bar{c}),(c\bar{d}),(d\bar{c}))$

$(R\bar{R},\ G\bar{B},\ B\bar{G})$

$g(cus;0)_{\text{color}}$

$((c\bar{u}),(u\bar{s}),(s\bar{c}))$

$(R\bar{G},\ G\bar{B},\ B\bar{R})$

$g(ccs;0)_{\text{color}}$

$((c\bar{c}),(c\bar{s}),(s\bar{c}))$

$(G\bar{G},\ R\bar{B},\ B\bar{R})$

hexaplet gulon

$g(cdd;0)_{\text{color}}$

$((c\bar{d}),(d\bar{d}),(d\bar{c}))$

$(G\bar{B},\ R\bar{R},\ B\bar{G})$

$g(cud;0)^{\text{linear combination}}_{\text{color}}$

$((c\bar{u}),(u\bar{d}),(d\bar{c}))$

$(R\bar{G},\ B\bar{B},\ G\bar{R})$

$((u\bar{c}),(d\bar{u}),(c\bar{d}))$

$(G\bar{R},\ B\bar{B},\ R\bar{G})$

$g(cuu;0)_{\text{color}}$

$((c\bar{u}),(u\bar{u}),(u\bar{c}))$

$(R\bar{G},\ B\bar{B},\ G\bar{R})$

$g(cds;0)_{\text{color}}$

$((c\bar{d}),(d\bar{s}),(s\bar{c}))$

$(G\bar{B},\ R\bar{G},\ B\bar{R})$

$g(cus;0)_{\text{color}}$

$((c\bar{u}),(u\bar{s}),(s\bar{c}))$

$(R\bar{G},\ G\bar{B},\ B\bar{R})$

$g(css;0)_{\text{color}}$

$((c\bar{s}),(s\bar{s}),(s\bar{c}))$

$(R\bar{B},\ G\bar{G},\ B\bar{R})$

Figure 4. 1: weight diagram of corlor ground state $g(qqq;0)_{\text{color}}$ for gluon singlet, triplet and hexaplet of SU(4)

And decuplet gulon

$g(ddd)_{\text{color}}$
$(\ (d\bar{d}),\ (d\bar{d}),\ (d\bar{d})\ )$
$(\ R\bar{R},\ G\bar{G},\ B\bar{B}\ )$

$g(udd)_{\text{color}}$
$(\ (u\bar{d}),\ (d\bar{d}),\ (d\bar{u})\ )$
$(\ R\bar{G},\ B\bar{B},\ G\bar{R}\ )$

$g(uud)_{\text{color}}$
$(\ (u\bar{u}),\ (u\bar{d}),\ (d\bar{u})\ )$
$(\ B\bar{B},\ R\bar{G},\ G\bar{R}\ )$

$g(uuu)_{\text{color}}$
$(\ (u\bar{u}),\ (u\bar{u}),\ (u,\bar{u})\ )$
$(\ R\bar{R},\ G\bar{G},\ B\bar{B}\ )$

$g(dds)_{\text{color}}$
$(\ (d\bar{d}),\ (d\bar{s}),\ (s\bar{d})\ )$
$(\ B\bar{B},\ R\bar{G},\ G\bar{R}\ )$

$g(uds)_{\text{color}}^{\text{linear combination}}$
$(\ (u\bar{d}),\ (d\bar{s}),\ (s\bar{u})\ )$
$(\ R\bar{R},\ G\bar{B},\ B\bar{G}\ )$
$(\ (d\bar{u}),\ (s\bar{d}),\ (u\bar{s})\ )$
$(\ R\bar{R},\ B\bar{G},\ G\bar{B}\ )$

$g(uus)_{\text{color}}$
$(\ (u\bar{u}),\ (u\bar{s}),\ (s\bar{u})\ )$
$(\ B\bar{B},\ G\bar{B},\ B\bar{G}\ )$

$g(dss)_{\text{color}}$
$(\ (d\bar{s}),\ (s\bar{s}),\ (s\bar{d})\ )$
$(\ R\bar{G},\ B\bar{B},\ G\bar{R}\ )$

$g(uss)_{\text{color}}$
$(\ (u\bar{s}),\ (s\bar{s}),\ (s\bar{u})\ )$
$(\ G\bar{B},\ R\bar{R},\ B\bar{G}\ )$

$g(sss)_{\text{color}}$
$(\ (s\bar{s}),\ (s\bar{s}),\ (s\bar{s})\ )$
$(\ R\bar{R},\ G\bar{G},\ B\bar{B}\ )$

Figure 4. 2: Weght diagram of ground state $g(qqq;0)_{\text{color}}$ for gluon decuplet of SU(4)

10. Spin of Gluon SU(4), A Highly Symmetric Figure

We obtain a highly symmetric figure of the presentation of spin angular momentum of gluon SU(4). Referring to 1) in section **8**

$ggg(ccc)$ +3
$(0, -1, +4)$

$ggg(ccd)$ 0 $\quad$ $ggg(ccu)$ +4
$(-1, -1, +2)$ $\quad$ $(+1, 0, +3)$

$ggg(ccs)$ +1
$(0, -1, +2)$

$ggg(cdd)$ –3 $\quad$ $ggg(cud)$ +1 $\quad$ $ggg(cuu)$ +5
$(-2, -1, 0)$ $\quad$ $(0, 0, +1)$ $\quad$ $(+2, +1, +2)$

$ggg(cds)$ –2 $\quad$ $ggg(cus)$ +2
$(-1, -1, 0)$ $\quad$ $(+1, 0, +1)$

$ggg(css)$ –1
$(0, -1, 0)$

$ggg(ddd)$ –6 $\quad$ $ggg(udd)$ –2 $\quad$ $ggg(uud)$ +2 $\quad$ $ggg(uuu)$ +6
$(-3, -1, -2)$ $\quad$ $(-1, 0, -1)$ $\quad$ $(+1, +1, 0)$ $\quad$ $(+3, +2, +1)$

$ggg(dds)$ –5 $\quad$ $ggg(uds)$ –1 $\quad$ $ggg(uus)$ +3
$(-2, -1, -2)$ $\quad$ $(0, 0, -1)$ $\quad$ $(+2, +1, 0)$

$ggg(dss)$ –4 $\quad$ $ggg(uss)$ 0
$(-1, -1, -2)$ $\quad$ $(+1, 0, -1)$

$ggg(sss)$ –3
$(0, -1, -2)$

Figure 5: Weight diagram for spin angular momentum $ggg(qqq)$ of gluon SU(4)

To illustrate symmetric properties in above table, we first consider horizontal polynomial sequences below. For clearer view, using symbol $qqq*$ to instead of $ggg(qqq)$

one polynomial
$$\begin{matrix} ccc* \ +3 \\ (0,-1,+4) \end{matrix}$$

two polynomials
$$\begin{matrix} ccd* \ 0 & ccu* \ +4 \\ (-1,-1,+2) & (+1,0,+3) \end{matrix} \ , \quad \begin{matrix} cds* \ -2 & cus* \ +2 \\ (-1,-1,0) & (+1,0,+1) \end{matrix} \ , \quad \begin{matrix} dss* \ -4 & uss* \ 0 \\ (-1,-1,-2) & (+1,0,-1) \end{matrix}$$

three polynomials
$$\begin{matrix} cdd* \ -3 & cud* \ +1 & cuu* \ +5 \\ (-2,-1,0) & (0,0,+1) & (+2,+1,+2) \end{matrix} \ , \quad \begin{matrix} dds* \ -5 & uds* \ -1 & uus* \ +3 \\ (-2,-1,-2) & (0,0,-1) & (+2,+1,0) \end{matrix}$$

four polynomials
$$\begin{matrix} ddd* \ -6 & udd* \ -2 & uud* \ +2 & uuu* \ +6 \\ (-3,-1,-2) & (-1,0,-1) & (+1,+1,0) & (+3,+2,+1) \end{matrix}$$

Arrange the above polynomials as following geometric toy bricks

$$\begin{matrix} & & & ccc* \ +3 \\ & & & (0,-1,+4) \\ & & ccd* \ 0 & ccu* \ +4 \\ & & (-1,-1,+2) & (+1,0,+3) \\ & cdd* \ -3 & cud* \ +1 & cuu* \ +5 \\ & (-2,-1,0) & (0,0,+1) & (+2,+1,+2) \\ ddd* \ -6 & udd* \ -2 & uud* \ +2 & uuu* \ +6 \\ (-3,-1,-2) & (-1,0,-1) & (+1,+1,0) & (+3,+2,+1) \end{matrix} \qquad \begin{matrix} ccc* \ +3 \\ (0,-1,+4) \\ ccd* \ 0 & ccu* \ +4 \\ (-1,-1,+2) & (+1,0,+3) \\ cdd* \ -3 & cud* \ +1 & cuu* \ +5 \\ (-2,-1,0) & (0,0,+1) & (+2,+1,+2) \\ ddd* \ -6 & udd* \ -2 & uud* \ +2 & uuu* \ +6 \\ (-3,-1,-2) & (-1,0,-1) & (+1,+1,0) & (+3,+2,+1) \end{matrix}$$

Figure 6: Gulon spin symmetric polynomial of Figure.5

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Further we see regulations

1) right inclination sequence from top left to bottom right

$$\begin{array}{cccc} ccc* \ +3 & ccu* \ +4 & cuu* \ +5 & uuu* \ +6 \\ (0,-1,+4) & (+1,0,+3) & (+2,+1,+2) & (+3,+2,+1) \end{array}$$

2) left inclination sequence from top right to bottom left

$$\begin{array}{cccc} ccc* \ +3 & ccd* \ 0 & cdd* \ -3 & ddd* \ -6 \\ (0,-1,+4) & (-1,-1,+2) & (-2,-1,0) & (-3,-1,-2) \end{array}$$

3) right inclination sequence from bottom right to top left

$$\begin{array}{ccccccccc} ccs* \ +1 & ccd* \ 0 & css* \ -1 & cds* \ -2 & cdd* \ -3 & sss* \ -3 & dss* \ -4 & dds* \ -5 & ddd* \ -6 \\ (0,-1,+2) & (-1,-1,+2) & (0,-1,0) & (-1,-1,0) & (-2,-1,\ 0) & (0,-1,-2) & (-1,-1,-2) & (-2,-1,-2) & (-3,-1,-2) \end{array}$$

4) left inclination sequence from bottom left to top right

$$\begin{array}{ccccccccc} ccs* \ +1 & ccu* \ +4 & css* \ -1 & cus* \ +2 & cuu* \ +5 & sss* \ -3 & uss* \ 0 & uus* \ +3 & uuu* \ +6 \\ (0,-1,+2) & (+1,\ 0,+3) & (0,-1,0) & (+1,0,+1) & (+2,+1,+2) & (0,-1,-2) & (+1,\ 0,-1) & (+2,+1,\ 0) & (+3,+2,+1) \end{array}$$

And 5)
$$\begin{array}{cc} ccd* \ 0 & ccs* \ +1 \\ (-1,-1,+2) & (0,-1,+2) \end{array}, \quad \begin{array}{cc} cud* \ +1 & cus* \ +2 \\ (0,0,+1) & (+1,0,+1) \end{array}, \quad \begin{array}{cc} uud* \ +2 & uus* \ +3 \\ (+1,+1,0) & (+2,+1,0) \end{array}$$

6)
$$\begin{array}{cc} dds* \ -5 & udd* \ -2 \\ (-2,-1,-2) & (-1,0,-1) \end{array}, \quad \begin{array}{cc} cds* \ -2 & cud* \ +1 \\ (-1,-1,0) & (0,0,+1) \end{array}, \quad \begin{array}{cc} ccs* \ +1 & ccu* \ +4 \\ (0,-1,+2) & (+1,0,+3) \end{array}$$

And 7)
$$\begin{array}{ccc} cdd* \ -3 & cds* \ -2 & css* \ -1 \\ (-2,-1,0) & (-1,-1,0) & (0,-1,\ 0) \end{array}, \quad \begin{array}{ccc} udd* \ -2 & uds* \ -1 & uss* \ 0 \\ (-1,0,-1) & (0,0,-1) & (+1,\ 0,-1) \end{array}$$

8)
$$\begin{array}{ccc} dss* \ -4 & uds* \ -1 & uud* \ +2 \\ (-1,-1,-2) & (0,0,-1) & (+1,+1,0) \end{array}, \quad \begin{array}{ccc} css* \ -1 & cus* \ +2 & cuu* \ +5 \\ (0,-1,0) & (+1,0,+1) & (+2,+1,+2) \end{array}$$

11. Observable Experimental Baryons

Now from Figure.5 and Figure.4.1, Figure.4.2, we obtain Figure.7 $S_3(ggg, g(qqq.\,0)_{\text{color}})$ below

$S_3(ggg, g(ccc.\,0)_{\text{color}})$ $\frac{+3}{3}$

$S_3(ggg, g(ccd.\,0)_{\text{color}})$ $\frac{0}{3}$ $S_3(ggg, g(ccu.\,0)_{\text{color}})$ $\frac{+4}{3}$

$S_3(ggg, g(ccs.\,0)_{\text{color}})$ $\frac{+1}{3}$

$S_3(ggg, g(cdd.\,0)_{\text{color}})$ $\frac{-3}{3}$ $S_3(ggg, g(cud.\,0)_{\text{color}})$ $\frac{+1}{3}$ $S_3(ggg, g(cuu.\,0)_{\text{color}})$ $\frac{+5}{3}$

$S_3(ggg, g(cds.\,0)_{\text{color}})$ $\frac{-2}{3}$ $S_3(ggg, g(cus.\,0)_{\text{color}})$ $\frac{+2}{3}$

$S_3(ggg, g(css.\,0)_{\text{color}})$ $\frac{-1}{3}$

$S_3(ggg,g(ddd.0)_{\text{color}})$ $\frac{-6}{3}$ $S_3(ggg,g(udd.0)_{\text{color}})$ $\frac{-2}{3}$ $S_3(ggg,g(uud.0)_{\text{color}})$ $\frac{+2}{3}$ $S_3(ggg,g(uuu.0)_{\text{color}})$ $\frac{+6}{3}$

$S_3(ggg, g(dds.\,0)_{\text{color}})$ $\frac{-5}{3}$ $S_3(ggg, g(uds.\,0)_{\text{color}})$ $\frac{-1}{3}$ $S_3(ggg, g(uus.\,0)_{\text{color}})$ $\frac{+3}{3}$

$S_3(ggg, g(dss.\,0)_{\text{color}})$ $\frac{-4}{3}$ $S_3(ggg, g(uss.\,0)_{\text{color}})$ $\frac{0}{3}$

$S_3(ggg, g(sss.\,0)_{\text{color}})$ $\frac{-3}{3}$

Figure 7: Weight diagram of spin $S_3(ggg, g(qqq.\,0)_{\text{color}})$ of charmed colored gluon SU(4)

And using $S_3(qqq, qqq_{\text{color}})^*$ Figure.3 Part.A and $S_3(ggg, g(qqq.0)_{\text{color}})$ Figure.7, the left part【1】of Table.3 Part.B can be finished, which can be written by using (11) below, further obtain Figure.8 $S_3(qqq,$ experimental)

$S_3(ccc,$ expe.) $\frac{+3}{2}$

$S_3(ccd,$ expe.) $\frac{+1}{2}$ $S_3(ccu,$ expe.) $\frac{+3}{2}$

$S_3(ccs,$ expe.) $\frac{+1}{2}$

$S_3(cdd,$ expe.) $\frac{-1}{2}$ $S_3(cud,$ expe.) $\frac{+1}{2}$ $S_3(cuu,$ expe.) $\frac{+3}{2}$

$S_3(cds,$ expe.) $\frac{-1}{2}$ $S_3(cus,$ expe.) $\frac{+1}{2}$

$S_3(css,$ expe.) $\frac{-1}{2}$

$S_3(ddd,$ expe.) $\frac{-3}{2}$ $S_3(udd,$ expe.) $\frac{-1}{2}$ $S_3(uud,$ expe.) $\frac{+1}{2}$ $S_3(uuu,$ expe.) $\frac{+3}{2}$

$S_3(dds,$ expe.) $\frac{-3}{2}$ $S_3(uds,$ expe.) $\frac{-1}{2}$ $S_3(uus,$ expe.) $\frac{+1}{2}$

$S_3(dss,$ expe.) $\frac{-3}{2}$ $S_3(uss,$ expe.) $\frac{-1}{2}$

$S_3(sss,$ expe.) $\frac{-3}{2}$

Figure 8: weight diagram of the third components $S_3(qqq,$ experimental) of observed charmed corlored baryon SU(4)

The above values of $S_3(qqq,$ experiment) are obtained by using formula (11)

$$S_3(qqq,\ \text{experimental})_{【1】} = \frac{1}{2}\{ S_3(qqq, qqq_{\text{color}})^* + S_3(ggg, g(qqq.0)_{\text{color}}) \} \quad (11)$$

【***Emphasis***】The spin experimental values of Figure.8 weight diagram are consistent with formula (4) Part.A

Next, back to section.4, we discuss the right part【2】of Table.3 Part.B following:

This time, we consider *spin coupling* $qqq + ggg$ between quark qqq Figure 9 and gluon $ggg(qqq)$ (Figure 5), then obtain Figure.11 $qqq + ggg$ (below). And consider *color coupling* $qqq_{\text{color}} + ggg_{\text{color}}$ between quark qqq_{color} Figure.10 and gluon ggg_{color}(Figure.4.1, Figure.4.2), then obtain Figure.12 $qqq_{\text{color}} + ggg_{\text{color}}$ (below).

Analogy to the similar proceeds in【1】previously, here by【2】, following from Figure.11, we get $S_3(qqq, ggg)$ (Figure.13), and from Figure.12 get $S_3(qqq_{\text{color}}, ggg_{\text{color}})$ (Figure.14). At last, Using formula (12) to calculate the third component S_3 of charmed corlored baryon SU(4)

$$S_3(qqq,\ \text{experimental})_{【2】} = \frac{1}{2}\{ S_3(qqq, ggg) + S_3(qqq_{\text{color}}, ggg_{\text{color}}) \} \quad (12)$$

Then comparing $S_3(qqq,$ experimental $)_{【2】}$ with $S_3(qqq,$ experimental $)_{【1】}$, it is shown: the result (12) is the same as the result (11), which is presented by Figure.8. that is

$$S_3(qqq,\ \text{experimental})_{【2】} = S_3(qqq,\ \text{experimental})_{【1】} = \text{Figure.9} \quad (13)$$

Summary

Because the concrete presentations of qqq(Figure.9), qqq_{color}(Figure.10) and ggg(Figure.5), ggg_{color}(Figure.4.1, Figure.4.2) could be found out, we can use Table.3 to discuss observable experimental baryons.

To construct experimental baryon, the routine result of coupling【1】between corled quark $qqq + qqq_{\text{colored}}$ and colored gulon $ggg + ggg_{\text{colored}}$ is identical to【2】between spin coupling $qqq + ggg$ and color coupling $qqq_{\text{color}} + ggg_{\text{color}}$.

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$ccc\ \Omega^{++}_{ccc}$ +3/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{+1}{2}\right)$

$ccd\ \Sigma^{*+}_{cc}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$ccu\ \Sigma^{*++}_{cc}$ +3/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{+1}{2}\right)$

$ccs\ \Omega^{+}_{cc}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$cdd\ \Sigma^{*0}_{c}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$cud\ \Sigma^{*+}_{c}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$cuu\ \Sigma^{*++}_{c}$ +3/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{+1}{2}\right)$

$cds\ \Xi^{*0}_{c}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$cus\ \Xi^{*+}_{c}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$css\ \Omega^{0}_{c}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$ddd\ \Delta^{-}$ –3/2
$\left(\frac{-1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$udd\ \Delta^{0}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$uud\ \Delta^{+}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$uuu\ \Delta^{++}$ +3/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{+1}{2}\right)$

$dds\ \Sigma^{*-}$ –3/2
$\left(\frac{-1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

.

$uds\ \Sigma^{*0}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$uus\ \Sigma^{*+}$ +1/2
$\left(\frac{+1}{2}, \frac{+1}{2}, \frac{-1}{2}\right)$

$dss\ \Xi^{*-}$ –3/2
$\left(\frac{-1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$uss\ \Xi^{*0}$ –1/2
$\left(\frac{+1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

$sss\ \Omega^{-}$ –3/2
$\left(\frac{-1}{2}, \frac{-1}{2}, \frac{-1}{2}\right)$

Figure 9: spin angular momentum qqq of charmed corlored baryon SU(4)

ccc_{color} Ω^{++}_{ccc} +27/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+19}{6}\right)$

ccd_{color} Σ^{*+}_{cc} +15/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+7}{6}\right)$

ccu_{color} Σ^{*++}_{cc} +21/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+13}{6}\right)$

ccs_{color} Ω^{+}_{cc} +9/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+1}{6}\right)$

cdd_{color} Σ^{*0}_{c} +3/6
$\left(\frac{+1}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$

cud_{color} Σ^{*+}_{c} +9/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+7}{6}\right)$

cuu_{color} Σ^{*++}_{c} +15/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+13}{6}\right)$

cds_{color} Ξ^{*0}_{c} –3/6
$\left(\frac{+1}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$

cus_{color} Ξ^{*+}_{c} +3/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+1}{6}\right)$

css_{color} Ω^{0}_{c} –9/6
$\left(\frac{+1}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$

ddd_{color} Δ^{-} –9/6
$\left(\frac{-11}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$

udd_{color} Δ^{0} –3/6
$\left(\frac{-5}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$

uud_{color} Δ^{+} +3/6
$\left(\frac{-5}{6}, \frac{+1}{6}, \frac{+7}{6}\right)$

uuu_{color} Δ^{++} +9/6
$\left(\frac{-5}{6}, \frac{+1}{6}, \frac{+13}{6}\right)$

dds_{color} Σ^{*-} –15/6
$\left(\frac{-11}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$

uds_{color} Σ^{*0} –9/6
$\left(\frac{-5}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$

uus_{color} Σ^{*+} –3/6
$\left(\frac{-5}{6}, \frac{+1}{6}, \frac{+1}{6}\right)$

dss_{color} –21/6 Ξ^{*-}
$\left(\frac{-11}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$

uss_{color} –15/6 Ξ^{*0}
$\left(\frac{-5}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$

sss_{color} –27/6 Ω^{0}_{c}
$\left(\frac{-17}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$

Figure 10: weight diagram of color spin qqq_{color} of charmed colored baryon SU(4)

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$$ccc + ggg \ \tfrac{+9}{2} \quad \left(\tfrac{+1}{2}, \tfrac{-1}{2}, \tfrac{+9}{2}\right)$$

$$ccd + ggg \ \tfrac{+1}{2} \quad \left(\tfrac{-1}{2}, \tfrac{-1}{2}, \tfrac{+3}{2}\right) \qquad ccu + ggg \ \tfrac{+11}{2} \quad \left(\tfrac{+3}{2}, \tfrac{+1}{2}, \tfrac{+7}{2}\right)$$

$$ccs + ggg \ \tfrac{+3}{2} \quad \left(\tfrac{+1}{2}, \tfrac{-1}{2}, \tfrac{+3}{2}\right)$$

$$cdd + ggg \ \tfrac{-7}{2} \quad \left(\tfrac{-3}{2}, \tfrac{-3}{2}, \tfrac{-1}{2}\right) \qquad cud + ggg \ \tfrac{+3}{2} \quad \left(\tfrac{+1}{2}, \tfrac{+1}{2}, \tfrac{+1}{2}\right) \qquad cuu + ggg \ \tfrac{+13}{2} \quad \left(\tfrac{+5}{2}, \tfrac{+3}{2}, \tfrac{+5}{2}\right)$$

$$cds + ggg \ \tfrac{-5}{2} \quad \left(\tfrac{-1}{2}, \tfrac{-3}{2}, \tfrac{-1}{2}\right) \qquad cus + ggg \ \tfrac{+5}{2} \quad \left(\tfrac{+3}{2}, \tfrac{+1}{2}, \tfrac{+1}{2}\right)$$

$$css + ggg \ \tfrac{-3}{2} \quad \left(\tfrac{+1}{2}, \tfrac{-3}{2}, \tfrac{-1}{2}\right)$$

$$ddd + ggg \ \tfrac{-15}{2} \quad \left(\tfrac{-7}{2}, \tfrac{-3}{2}, \tfrac{-5}{2}\right) \qquad udd + ggg \ \tfrac{-5}{2} \quad \left(\tfrac{-1}{2}, \tfrac{-1}{2}, \tfrac{-3}{2}\right) \qquad uud + ggg \ \tfrac{+5}{2} \quad \left(\tfrac{+3}{2}, \tfrac{+3}{2}, \tfrac{-1}{2}\right) \qquad uuu + ggg \ \tfrac{+15}{2} \quad \left(\tfrac{+7}{2}, \tfrac{+5}{2}, \tfrac{+3}{2}\right)$$

$$dds + ggg \ \tfrac{-13}{2} \quad \left(\tfrac{-5}{2}, \tfrac{-3}{2}, \tfrac{-5}{2}\right) \qquad uds + ggg \ \tfrac{-3}{2} \quad \left(\tfrac{+1}{2}, \tfrac{-1}{2}, \tfrac{-3}{2}\right) \qquad uus + ggg \ \tfrac{+7}{2} \quad \left(\tfrac{+5}{2}, \tfrac{+3}{2}, \tfrac{-1}{2}\right)$$

$$dss + ggg \ \tfrac{-11}{2} \quad \left(\tfrac{-3}{2}, \tfrac{-3}{2}, \tfrac{-5}{2}\right) \qquad uss + ggg \ \tfrac{-1}{2} \quad \left(\tfrac{+3}{2}, \tfrac{-1}{2}, \tfrac{-3}{2}\right)$$

$$sss + ggg \ \tfrac{-9}{2} \quad \left(\tfrac{-1}{2}, \tfrac{-3}{2}, \tfrac{-5}{2}\right)$$

Figure 11: $qqq + ggg$ of charmed corlored baryon SU(4)

$$ccc_{\text{color}} + ggg_{\text{color}} \quad +27/6 \quad \left(\frac{+1}{6}, \frac{+7}{6}, \frac{+19}{6}\right)$$

$$ccd_{\text{color}} + ggg_{\text{color}} \quad +15/6 \quad \left(\frac{+1}{6}, \frac{+7}{6}, \frac{+7}{6}\right)$$

$$ccu_{\text{color}} + ggg_{\text{color}} \quad +21/6 \quad \left(\frac{+1}{6}, \frac{+7}{6}, \frac{+13}{6}\right)$$

$$ccs_{\text{color}} + ggg_{\text{color}} \quad +9/6 \quad \left(\frac{+1}{6}, \frac{+7}{6}, \frac{+1}{6}\right)$$

$$cdd_{\text{color}} + ggg_{\text{color}} \quad +3/6 \quad \left(\frac{+1}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$$

$$cud_{\text{color}} + ggg_{\text{color}} \quad +9/6 \quad \left(\frac{+1}{6}, \frac{+1}{6}, \frac{+7}{6}\right)$$

$$cuu_{\text{color}} + ggg_{\text{color}} \quad +15/6 \quad \left(\frac{+1}{6}, \frac{+1}{6}, \frac{+13}{6}\right)$$

$$cds_{\text{color}} + ggg_{\text{color}} \quad -3/6 \quad \left(\frac{+1}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$$

$$cus_{\text{color}} + ggg_{\text{color}} \quad +3/6 \quad \left(\frac{+1}{6}, \frac{+1}{6}, \frac{+1}{6}\right)$$

$$css_{\text{color}} + ggg_{\text{color}} \quad -9/6 \quad \left(\frac{+1}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$$

$$ddd_{\text{color}} + ggg_{\text{color}} \quad -9/6 \quad \left(\frac{-11}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$$

$$udd_{\text{color}} + ggg_{\text{color}} \quad -3/6 \quad \left(\frac{-5}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$$

$$uud_{\text{color}} + ggg_{\text{color}} \quad +3/6 \quad \left(\frac{-5}{6}, \frac{+1}{6}, \frac{+7}{6}\right)$$

$$uuu_{\text{color}} + ggg_{\text{color}} \quad +9/6 \quad \left(\frac{-5}{6}, \frac{+1}{6}, \frac{+13}{6}\right)$$

$$dds_{\text{color}} + ggg_{\text{color}} \quad -15/6 \quad \left(\frac{-11}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$$

$$uds_{\text{color}} + ggg_{\text{color}} \quad -9/6 \quad \left(\frac{-5}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$$

$$uus_{\text{color}} + ggg_{\text{color}} \quad -3/6 \quad \left(\frac{-5}{6}, \frac{+1}{6}, \frac{+1}{6}\right)$$

$$dss_{\text{color}} + ggg_{\text{color}} \quad -21/6 \quad \left(\frac{-11}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$$

$$uss_{\text{color}} + ggg_{\text{color}} \quad -15/6 \quad \left(\frac{-5}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$$

$$sss_{\text{color}} + ggg_{\text{color}} \quad -27/6 \quad \left(\frac{-17}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$$

Figure 12: $qqq_{\text{color}} + ggg_{\text{color}}$ of charmed corlored baryon SU(4)

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Then obtain S_3 of Figure.11:

$$S_3(ccc, ggg) \quad \frac{+9}{6}$$

$$S_3(ccd, ggg) \quad \frac{+1}{6} \qquad S_3(ccu, ggg) \quad \frac{+11}{6}$$

$$S_3(ccs, ggg) \quad \frac{+3}{6}$$

$$S_3(cdd, ggg) \quad \frac{-7}{6} \qquad S_3(cud, ggg) \quad \frac{+3}{6} \qquad S_3(cuu, ggg) \quad \frac{+13}{6}$$

$$S_3(cds, ggg) \quad \frac{-5}{6} \qquad S_3(cus, ggg) \quad \frac{+5}{6}$$

$$S_3(css, ggg) \quad \frac{-3}{6}$$

$$S_3(ddd, ggg) \quad \frac{-15}{6} \qquad S_3(udd, ggg) \quad \frac{-5}{6} \qquad S_3(uud, ggg) \quad \frac{+5}{6} \qquad S_3(uuu, ggg) \quad \frac{+15}{6}$$

$$S_3(dds, ggg) \quad \frac{-13}{6} \qquad S_3(uds, ggg) \quad \frac{-3}{6} \qquad S_3(uus, ggg) \quad \frac{+7}{6}$$

$$S_3(dss, ggg) \quad \frac{-11}{6} \qquad S_3(uss, ggg) \quad \frac{-1}{6}$$

$$S_3(sss, ggg) \quad \frac{-9}{6}$$

Figure 13: $S_3(qqq, ggg)$ of spin coupling

and obtain S_3 of Figure.12:

$S_3(ccc_{\text{color}}, ggg_{\text{color}})$ +9/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+19}{6}\right)$

$S_3(ccd_{\text{color}}, ggg_{\text{color}})$ +5/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+7}{6}\right)$

$S_3(ccu_{\text{color}}, ggg_{\text{color}})$ +7/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+13}{6}\right)$

$S_3(ccs_{\text{color}}, ggg_{\text{color}})$ +3/6
$\left(\frac{+1}{6}, \frac{+7}{6}, \frac{+1}{6}\right)$

$S_3(cdd_{\text{color}}, ggg_{\text{color}})$ +1/6
$\left(\frac{+1}{6}, \frac{-5}{6}, \frac{+7}{6}\right)$

$S_3(cud_{\text{color}}, ggg_{\text{color}})$ +3/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+7}{6}\right)$

$S_3(cuu_{\text{color}}, ggg_{\text{color}})$ +5/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+13}{6}\right)$

$S_3(cds_{\text{color}}, ggg_{\text{color}})$ –1/6
$\left(\frac{+1}{6}, \frac{-5}{6}, \frac{+1}{6}\right)$

$S_3(cus_{\text{color}}, ggg_{\text{color}})$ +1/6
$\left(\frac{+1}{6}, \frac{+1}{6}, \frac{+1}{6}\right)$

$S_3(css_{\text{color}}, ggg_{\text{color}})$ –3/6
$\left(\frac{+1}{6}, \frac{-11}{6}, \frac{+1}{6}\right)$

$S_3(ddd_{\text{color}}, ggg_{\text{color}})$ $\frac{-3}{6}$

$S_3(udd_{\text{color}}, ggg_{\text{color}})$ $\frac{-1}{6}$

$S_3(uud_{\text{color}}, ggg_{\text{color}})$ $\frac{+1}{6}$

$S_3(uuu_{\text{color}}, ggg_{\text{color}})$ $\frac{+3}{6}$

$S_3(dds_{\text{color}}, ggg_{\text{color}})$ $\frac{-5}{6}$

$S_3(uds_{\text{color}}, ggg_{\text{color}})$ $\frac{-3}{6}$

$S_3(uus_{\text{color}}, ggg_{\text{color}})$ $\frac{-1}{6}$

$S_3(dss_{\text{color}}, ggg_{\text{color}})$ $\frac{-7}{6}$

$S_3(uss_{\text{color}}, ggg_{\text{color}})$ $\frac{-5}{6}$

$S_3(sss_{\text{color}}, ggg_{\text{color}})$ $\frac{-9}{6}$

Figure 14: $S_3(qqq_{\text{color}}, ggg_{\text{color}})$ of color coupling

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Part.D Meson Constituent Related to Gluon

12. Spin Color State, Spin of Colored Meson $q\overline{q} + q\overline{q}_{\,color}$ Nonet

In order to discuss colored mesons, we extend ★ Table.2 (Part.A) colored quarks $q(\chi,\alpha)$ into Table.6 and Table.7 below

■1

	spin $\uparrow$			$t(\uparrow)\ \frac{+1}{2}$			$c(\uparrow)\ \frac{+1}{2}$			$u(\uparrow)\ \frac{+1}{2}$		
colored quark	$q(\uparrow,\alpha)$	▲	$t(\uparrow,\mathrm{R})$ $\frac{+5}{3}$	$t(\uparrow,\mathrm{G})$ $\frac{+8}{3}$	$t(\uparrow,\mathrm{B})$ $\frac{+14}{3}$	$c(\uparrow,\mathrm{R})$ $\frac{+2}{3}$	$c(\uparrow,\mathrm{G})$ $\frac{+5}{3}$	$c(\uparrow,\mathrm{B})$ $\frac{+11}{3}$	$u(\uparrow,\mathrm{R})$ $\frac{-1}{3}$	$u(\uparrow,\mathrm{G})$ $\frac{+2}{3}$	$u(\uparrow,\mathrm{B})$ $\frac{+8}{3}$	▲ ★
	spin $\uparrow$			$b(\uparrow)\ \frac{+1}{2}$			$s(\uparrow)\ \frac{+1}{2}$			$d(\uparrow)\ \frac{+1}{2}$		
colored quark	$q(\uparrow,\alpha)$	▲	$b(\uparrow,\mathrm{R})$ $\frac{-10}{3}$	$b(\uparrow,\mathrm{G})$ $\frac{-7}{3}$	$b(\uparrow,\mathrm{B})$ $\frac{-1}{3}$	$s(\uparrow,\mathrm{R})$ $\frac{-7}{3}$	$s(\uparrow,\mathrm{G})$ $\frac{-4}{3}$	$s(\uparrow,\mathrm{B})$ $\frac{+2}{3}$	$d(\uparrow,\mathrm{R})$ $\frac{-4}{3}$	$d(\uparrow,\mathrm{G})$ $\frac{-1}{3}$	$d(\uparrow,\mathrm{B})$ $\frac{+5}{3}$	▲
——	• •			——	•		——	•		——		
	spin $\downarrow$			$\bar{t}(\downarrow)\ \frac{-1}{2}$			$\bar{c}(\downarrow)\ \frac{-1}{2}$			$\bar{u}(\downarrow)\ \frac{-1}{2}$		
colored quark	$q(\downarrow,\alpha)$	▼	$t(\downarrow,\mathrm{R})$ $\frac{+2}{3}$	$t(\downarrow,\mathrm{G})$ $\frac{+5}{3}$	$t(\downarrow,\mathrm{B})$ $\frac{+11}{3}$	$c(\downarrow,\mathrm{R})$ $\frac{-1}{3}$	$c(\downarrow,\mathrm{G})$ $\frac{+2}{3}$	$c(\downarrow,\mathrm{B})$ $\frac{+8}{3}$	$u(\downarrow,\mathrm{R})$ $\frac{-4}{3}$	$u(\downarrow,\mathrm{G})$ $\frac{-1}{3}$	$u(\downarrow,\mathrm{B})$ $\frac{+5}{3}$	▼
	spin $\downarrow$			$b(\downarrow)\ \frac{-1}{2}$			$s(\downarrow)\ \frac{-1}{2}$			$d(\downarrow)\ \frac{-1}{2}$		
colored quark	$q(\downarrow,\alpha)$	▼	$b(\downarrow,\mathrm{R})$ $\frac{-13}{3}$	$b(\downarrow,\mathrm{G})$ $\frac{-10}{3}$	$b(\downarrow,\mathrm{B})$ $\frac{-4}{3}$	$s(\downarrow,\mathrm{R})$ $\frac{-10}{3}$	$s(\downarrow,\mathrm{G})$ $\frac{-7}{3}$	$s(\downarrow,\mathrm{B})$ $\frac{-1}{3}$	$d(\downarrow,\mathrm{R})$ $\frac{-7}{3}$	$d(\downarrow,\mathrm{G})$ $\frac{-4}{3}$	$d(\downarrow,\mathrm{B})$ $\frac{+2}{3}$	▼ ★

■1 *Table 6:* colored quarks ▲ $q(\uparrow,\alpha)$ and colored quarks ▼ $q(\downarrow,\alpha)$

■2

	spin ↓			$\bar{t}(\downarrow)\ \frac{-1}{2}$		|		$\bar{c}(\downarrow)\ \frac{-1}{2}$		|		$\bar{u}(\downarrow)\ \frac{-1}{2}$		
colored anti-quark	$\bar{q}(\downarrow,\bar{\alpha})$	▲	$\bar{t}(\downarrow,\bar{\mathrm{R}})$ $\frac{-5}{3}$	$\bar{t}(\downarrow,\bar{\mathrm{G}})$ $\frac{-8}{3}$	$\bar{t}(\downarrow,\bar{\mathrm{B}})$ $\frac{-14}{3}$	|	$\bar{c}(\downarrow,\bar{\mathrm{R}})$ $\frac{-2}{3}$	$\bar{c}(\downarrow,\bar{\mathrm{G}})$ $\frac{-5}{3}$	$\bar{c}(\downarrow,\bar{\mathrm{B}})$ $\frac{-11}{3}$	|	$\bar{u}(\downarrow,\bar{\mathrm{R}})$ $\frac{+1}{3}$	$\bar{u}(\downarrow,\bar{\mathrm{G}})$ $\frac{-2}{3}$	$\bar{u}(\downarrow,\bar{\mathrm{B}})$ $\frac{-8}{3}$	▲
	spin ↓			$\bar{b}(\downarrow)\ \frac{-1}{2}$		|		$\bar{s}(\downarrow)\ \frac{-1}{2}$		|		$\bar{d}(\downarrow)\ \frac{-1}{2}$		
colored anti-quark	$\bar{q}(\downarrow,\bar{\alpha})$	▲	$\bar{b}(\downarrow,\bar{\mathrm{R}})$ $\frac{+10}{3}$	$\bar{b}(\downarrow,\bar{\mathrm{G}})$ $\frac{+7}{3}$	$\bar{b}(\downarrow,\bar{\mathrm{B}})$ $\frac{+1}{3}$	|	$\bar{s}(\downarrow,\bar{\mathrm{R}})$ $\frac{+7}{3}$	$\bar{s}(\downarrow,\bar{\mathrm{G}})$ $\frac{+4}{3}$	$\bar{s}(\downarrow,\bar{\mathrm{B}})$ $\frac{-2}{3}$	|	$\bar{d}(\downarrow,\bar{\mathrm{R}})$ $\frac{+4}{3}$	$\bar{d}(\downarrow,\bar{\mathrm{G}})$ $\frac{+1}{3}$	$\bar{d}(\downarrow,\bar{\mathrm{B}})$ $\frac{-5}{3}$	▲
———	• •			———		•		———		•		———		
	spin ↑			$\bar{t}(\uparrow)\ \frac{+1}{2}$		|		$\bar{c}(\uparrow)\ \frac{+1}{2}$		|		$\bar{u}(\uparrow)\ \frac{+1}{2}$		
colored anti-quark	$\bar{q}(\uparrow,\bar{\alpha})$	▼	$\bar{t}(\uparrow,\bar{\mathrm{R}})$ $\frac{-2}{3}$	$\bar{t}(\uparrow,\bar{\mathrm{G}})$ $\frac{-5}{3}$	$\bar{t}(\uparrow,\bar{\mathrm{B}})$ $\frac{-11}{3}$	|	$\bar{c}(\uparrow,\bar{\mathrm{R}})$ $\frac{+1}{3}$	$\bar{c}(\uparrow,\bar{\mathrm{G}})$ $\frac{-2}{3}$	$\bar{c}(\uparrow,\bar{\mathrm{B}})$ $\frac{-8}{3}$	|	$\bar{u}(\uparrow,\bar{\mathrm{R}})$ $\frac{+4}{3}$	$\bar{u}(\uparrow,\bar{\mathrm{G}})$ $\frac{+1}{3}$	$\bar{u}(\uparrow,\bar{\mathrm{B}})$ $\frac{-5}{3}$	▼
	spin ↑			$\bar{b}(\uparrow)\ \frac{+1}{2}$		|		$\bar{s}(\uparrow)\ \frac{+1}{2}$		|		$\bar{d}(\uparrow)\ \frac{+1}{2}$		
colored anti-quark	$q(\uparrow,\bar{\alpha})$	▼	$\bar{b}(\uparrow,\bar{\mathrm{R}})$ $\frac{+13}{3}$	$\bar{b}(\uparrow,\bar{\mathrm{G}})$ $\frac{+10}{3}$	$\bar{b}(\uparrow,\bar{\mathrm{B}})$ $\frac{+4}{3}$	|	$\bar{s}(\uparrow,\bar{\mathrm{R}})$ $\frac{+10}{3}$	$\bar{s}(\uparrow,\bar{\mathrm{G}})$ $\frac{+7}{3}$	$\bar{s}(\uparrow,\bar{\mathrm{B}})$ $\frac{+1}{3}$	|	$\bar{d}(\uparrow,\bar{\mathrm{R}})$ $\frac{+7}{3}$	$\bar{d}(\uparrow,\bar{\mathrm{G}})$ $\frac{+4}{3}$	$\bar{d}(\uparrow,\bar{\mathrm{B}})$ $\frac{-2}{3}$	▼

■2 *Table 7:* Colored antiquarks ▲ $\bar{q}(\downarrow,\bar{\alpha})$ and colored antiquarks ▼ $\bar{q}(\uparrow,\bar{\alpha})$

【***Emphasis***】Formula (4.0) Part.A is the domain of $q(\chi,\alpha)$ definition of *colored quark* in Table.6 and Table.7

Global Journal of Science Frontier Research (A) Volume XXIII Issue II Version I Year 2023

Because every colored meson comprises a colored quark and a colored antiquark, so colored meson (be written as an array that labelled by symbol $q\bar{q}+q\bar{q}_{\text{color}}$) could be obtained directly from the combinations of the colored quarks (Table.6) and the colored antiquarks (Table.7). Further, colored mesons are expressed by following four spin-color states of $q\bar{q}+q\bar{q}_{\text{color}}$ representations**:**

$$\{q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\beta})\},\ \{q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta})\},\ \{q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})\},\ \{q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta})\} \tag{14.0}$$

These spin-color states for $q\bar{q}+q\bar{q}_{\text{color}}$ meson composites satisfies condition (soon see below):

$$\tfrac{1}{2}\{\ \mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})) + \mathrm{S}_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta}))\ \} = \mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\beta})) = \mathrm{S}_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta})) \quad \alpha,\beta = \mathrm{R,G,B} \tag{14}$$

Now we are prepared to disscuss two special cases 《**A**》 $\alpha = \beta$ and 《**B**》 $\alpha \neq \beta$

《**A**》 $\{q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha})\}$ Figure.15, $\{q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})\}$ Figure.16, $\{q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})\}$ Figure.17, $\{q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha})\}$ Figure.18

《**B**》 $\{q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\beta})\}$ Figure.19, $\{q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta})\}$ Figure.20, $\{q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})\}$ Figure.21, $\{q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta})\}$ Figure.22

If only care for the results of 《**A**》 and 《**B**》 , refer to SUMMARY OF MESON at the end of this section.

《**A**》 $\alpha = \beta$ (Figure.15, 16, 17, 18 below)

《**A1**》 The spin angular momentum directions, between quark $q(\chi)$ and antiquark $\bar{q}(\chi)$, are anti-parallel:

$d(\uparrow,\alpha),\bar{s}(\downarrow,\bar{\alpha})$ +1

$(\frac{-4}{3},\frac{+7}{3})$

$(\frac{-1}{3},\frac{+4}{3})$

$(\frac{+5}{3},\frac{-2}{3})$

$u(\uparrow,\alpha),\bar{s}(\downarrow,\bar{\alpha})$ +2

$(\frac{-1}{3},\frac{+7}{3})$

$(\frac{+2}{3},\frac{+4}{3})$

$(\frac{+8}{3},\frac{-2}{3})$

$d(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})$ –1

$(\frac{-4}{3},\frac{+1}{3})$

$(\frac{-1}{3},\frac{-2}{3})$

$(\frac{+5}{3},\frac{-8}{3})$

$d(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})$ 0, $u(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})$ 0

$(\frac{-4}{3},\frac{+4}{3})$, $(\frac{-1}{3},\frac{+1}{3})$

$(\frac{-1}{3},\frac{+1}{3})$, $(\frac{+2}{3},\frac{-2}{3})$

$(\frac{+5}{3},\frac{-5}{3})$, $(\frac{+8}{3},\frac{-8}{3})$

$u(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})$ +1

$(\frac{-1}{3},\frac{+4}{3})$

$(\frac{+2}{3},\frac{+1}{3})$

$(\frac{+8}{3},\frac{-5}{3})$

$s(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})$ –2

$(\frac{-7}{3},\frac{+1}{3})$

$(\frac{-4}{3},\frac{-2}{3})$

$(\frac{+2}{3},\frac{-8}{3})$

$s(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})$ –1

$(\frac{-7}{3},\frac{+4}{3})$

$(\frac{-4}{3},\frac{+1}{3})$

$(\frac{+2}{3},\frac{-5}{3})$

Figure 15.1: $q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha})$ of colored mesons

Then obtain

$S_3(d(\uparrow,\alpha),\bar{s}(\downarrow,\bar{\alpha}))$ +1/2

$S_3(u(\uparrow,\alpha),\bar{s}(\downarrow,\bar{\alpha}))$ +1

$S_3(d(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$ –1/2

$S_3(d(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha}))$, $S_3(u(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$ 0, 0

$S_3(u(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha}))$ +1/2

$S_3(s(\uparrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$ –1

$S_3(s(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha}))$ –1/2

Figure 15.2: $S_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))\equiv S_3(\uparrow,\downarrow)$ of colored mesons

$d(\downarrow,\alpha),\bar{s}(\uparrow,\bar{\alpha})$ +1
$(\frac{-7}{3},\frac{+10}{3})$
$(\frac{-4}{3},\frac{+7}{3})$
$(\frac{+2}{3},\frac{+1}{3})$

$u(\downarrow,\alpha),\bar{s}(\uparrow,\bar{\alpha})$ +2
$(\frac{-4}{3},\frac{+10}{3})$
$(\frac{-1}{3},\frac{+7}{3})$
$(\frac{+5}{3},\frac{+1}{3})$

$d(\downarrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ –1
$(\frac{-7}{3},\frac{+4}{3})$
$(\frac{-4}{3},\frac{+1}{3})$
$(\frac{+2}{3},\frac{-5}{3})$

$d(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ 0, $u(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ 0
$(\frac{-7}{3},\frac{+7}{3})$, $(\frac{-4}{3},\frac{+4}{3})$
$(\frac{-4}{3},\frac{+4}{3})$, $(\frac{-1}{3},\frac{+1}{3})$
$(\frac{+2}{3},\frac{-2}{3})$, $(\frac{+5}{3},\frac{-5}{3})$

$u(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ +1
$(\frac{-4}{3},\frac{+7}{3})$
$(\frac{-1}{3},\frac{+4}{3})$
$(\frac{+5}{3},\frac{-2}{3})$

$s(\downarrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ –2
$(\frac{-10}{3},\frac{+4}{3})$
$(\frac{-7}{3},\frac{+1}{3})$
$(\frac{-1}{3},\frac{-5}{3})$

$s(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ –1
$(\frac{-10}{3},\frac{+7}{3})$
$(\frac{-7}{3},\frac{+4}{3})$
$(\frac{-1}{3},\frac{-2}{3})$

Figure 16.1: $q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})$ of colored mesons

Then obtain

$S_3(d(\downarrow,\alpha),\bar{s}(\uparrow,\bar{\alpha}))$
+1/2

$S_3(u(\downarrow,\alpha),\bar{s}(\uparrow,\bar{\alpha}))$
+1

$S_3(d(\downarrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
–1/2

$S_3(d(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$, $S_3(u(\downarrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
0, 0

$S_3(u(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$
+1/2

$S_3(s(\downarrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
–1

$S_3(s(\downarrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$
–1/2

Figure 16.2: $S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha}))\equiv S_3(\downarrow,\uparrow)$ of colored mesons

《**A2**》 The spin angular momentum directions, between quark $q(\chi)$ and antiquark $\bar{q}(\chi)$, are parallel:

$d(\uparrow,\alpha),\bar{s}(\uparrow,\bar{\alpha})$ +2
$(\frac{-4}{3},\frac{+10}{3})$
$(\frac{-1}{3},\frac{+7}{3})$
$(\frac{+5}{3},\frac{+1}{3})$

$u(\uparrow,\alpha),\bar{s}(\uparrow,\bar{\alpha})$ +3
$(\frac{-1}{3},\frac{+10}{3})$
$(\frac{+2}{3},\frac{+7}{3})$
$(\frac{+8}{3},\frac{+1}{3})$

$d(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ 0
$(\frac{-4}{3},\frac{+4}{3})$
$(\frac{-1}{3},\frac{+1}{3})$
$(\frac{+5}{3},\frac{-5}{3})$

$d(\uparrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})$ +1, $u(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ +1
$(\frac{-4}{3},\frac{+7}{3})$, $(\frac{-1}{3},\frac{+4}{3})$
$(\frac{-1}{3},\frac{+4}{3})$, $(\frac{+2}{3},\frac{+1}{3})$
$(\frac{+5}{3},\frac{-2}{3})$, $(\frac{+8}{3},\frac{-5}{3})$

$u(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ +2
$(\frac{-1}{3},\frac{+7}{3})$
$(\frac{+2}{3},\frac{+4}{3})$
$(\frac{+8}{3},\frac{-2}{3})$

$s(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ –1
$(\frac{-7}{3},\frac{+4}{3})$
$(\frac{-4}{3},\frac{+1}{3})$
$(\frac{+2}{3},\frac{-5}{3})$

$s(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ 0
$(\frac{-7}{3},\frac{+7}{3})$
$(\frac{-4}{3},\frac{+4}{3})$
$(\frac{+2}{3},\frac{-2}{3})$

Figure 17.1: $q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})$ of colored mesons

Then obtain

$S_3(d(\uparrow,\alpha),\bar{s}(\uparrow,\bar{\alpha}))$
+1

$S_3(u(\uparrow,\alpha),\bar{s}(\uparrow,\bar{\alpha}))$
+3/2

$S_3(d(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
0

$S_3(d(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$, $S_3(u(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
+1/2, +1/2

$S_3(u(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$
+1

$S_3(s(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha}))$
–1/2

$S_3(s(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha}))$
0

Figure 17.2: $S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha}))\equiv S_3(\uparrow,\uparrow)$ of colored mesons

$d(\downarrow,\alpha),\bar{s}(\downarrow,\bar{\alpha})\ \ 0$
$(\frac{-7}{3},\frac{+7}{3})$
$(\frac{-4}{3},\frac{+4}{3})$
$(\frac{+2}{3},\frac{-2}{3})$

$u(\downarrow,\alpha),\bar{s}(\downarrow,\bar{\alpha})\ \ +1$
$(\frac{-4}{3},\frac{+7}{3})$
$(\frac{-1}{3},\frac{+4}{3})$
$(\frac{+5}{3},\frac{-2}{3})$

$d(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})\ \ -2$
$(\frac{-7}{3},\frac{+1}{3})$
$(\frac{-4}{3},\frac{-2}{3})$
$(\frac{+2}{3},\frac{-8}{3})$

$d(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})\ \ -1,\ u(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})\ \ -1$
$(\frac{-7}{3},\frac{+4}{3}),\ (\frac{-4}{3},\frac{+1}{3})$
$(\frac{-4}{3},\frac{+1}{3}),\ (\frac{-1}{3},\frac{-2}{3})$
$(\frac{+2}{3},\frac{-5}{3}),\ (\frac{+5}{3},\frac{-8}{3})$

$u(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})\ \ 0$
$(\frac{-4}{3},\frac{+4}{3})$
$(\frac{-1}{3},\frac{+1}{3})$
$(\frac{+5}{3},\frac{-5}{3})$

$s(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha})\ \ -3$
$(\frac{-10}{3},\frac{+1}{3})$
$(\frac{-7}{3},\frac{-2}{3})$
$(\frac{-1}{3},\frac{-8}{3})$

$s(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})\ \ -2$
$(\frac{-10}{3},\frac{+4}{3})$
$(\frac{-7}{3},\frac{+1}{3})$
$(\frac{-1}{3},\frac{-5}{3})$

Figure 18.1: $q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha})$ of colored mesons

Then obtain

$S_3(d(\downarrow,\alpha),\bar{s}(\downarrow,\bar{\alpha}))$
0

$S_3(u(\uparrow,\alpha),\bar{s}(\downarrow,\bar{\alpha}))$
+1/2

$S_3(d(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$
–1

$S_3(d(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha})),\ S_3(u(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$
–1/2, –1/2

$S_3(u(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha}))$
0

$S_3(s(\downarrow,\alpha),\bar{u}(\downarrow,\bar{\alpha}))$
–3/2

$S_3(s(\downarrow,\alpha),\bar{d}(\downarrow,\bar{\alpha}))$
–1

Figure 18.2: $S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))\equiv S_3(\downarrow,\downarrow)$ of colored mesons

Summary《**A**》$\alpha = \beta$

$$\begin{array}{ccccc} & & q\bar{q} & & \\ & \alpha\bar{\alpha} & & \alpha\bar{\alpha} & \\ \alpha\bar{\alpha} & & \alpha\bar{\alpha} & & \alpha\bar{\alpha} \\ & \alpha\bar{\alpha} & & \alpha\bar{\alpha} & \end{array} = \begin{array}{ccccc} & & q\bar{q} & & \\ & +1 & & +3/2 & \\ 0 & & +1/2 & & +1 \\ & -1/2 & & 0 & \end{array} , \begin{array}{ccccc} & & q\bar{q} & & \\ & +1/2 & & +1 & \\ -1/2 & & 0 & & +1/2 \\ & -1 & & -1/2 & \end{array} , \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & +1/2 & \\ -1 & & -1/2 & & 0 \\ & -3/2 & & -1 & \end{array}$$

$S_3(q(\chi,\alpha),\bar{q}(\chi,\bar{\alpha}) =$ Figure.17.3 $S_3(\uparrow,\uparrow)$ Figure.15.3 $S_3(\uparrow,\downarrow)$, Figure.16.3 $S_3(\downarrow,\uparrow)$, Figure.18.3 $S_3(\downarrow,\downarrow)$

$$\tfrac{1}{2}\{\ S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})) + S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))\ \}$$

$$= \tfrac{1}{2}\left\{ \begin{array}{ccccc} & & q\bar{q} & & \\ & +1 & & +3/2 & \\ 0 & & +1/2 & & +1 \\ & -1/2 & & 0 & \end{array} + \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & +1/2 & \\ -1 & & -1/2 & & 0 \\ & -3/2 & & -1 & \end{array} \right\} = \tfrac{1}{2} \begin{array}{ccccc} & +1 & & +2 & \\ -1 & & 0 & & +1 \\ & -2 & & -1 & \end{array} = \begin{array}{ccccc} & +1/2 & & +1 & \\ -1/2 & & 0 & & +1/2 \\ & -1 & & -1/2 & \end{array}$$

$$= S_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}) = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha}) \tag{15}$$

$$\tfrac{1}{2}\{\ S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})) - S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))\ \}$$

$$= \tfrac{1}{2}\left\{ \begin{array}{ccccc} & & q\bar{q} & & \\ & +1 & & +3/2 & \\ 0 & & +1/2 & & +1 \\ & -1/2 & & 0 & \end{array} - \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & +1/2 & \\ -1 & & -1/2 & & 0 \\ & -3/2 & & -1 & \end{array} \right\} = \tfrac{1}{2} \begin{array}{ccccc} & +1 & & +1 & \\ +1 & & +1 & & +1 \\ & +1 & & +1 & \end{array} = \begin{array}{ccccc} & +1/2 & & +1/2 & \\ +1/2 & & +1/2 & & +1/2 \\ & +1/2 & & +1/2 & \end{array} \tag{16}$$

$$S_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}) = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha}) \tag{17}$$

$$S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})) - 1/2 = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha}))\ ,\ S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})) = S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\alpha})) + 1/2 \tag{18}$$

《**B**》 $\alpha \neq \beta$ (Figure.19, 20, 21, 22 below)

《**B1**》 The spin angular momentum directions, between quark $q(\chi)$ and antiquark $\bar{q}(\chi)$, are anti-parallel:

$d(\uparrow, \mathrm{R}), \bar{s}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{-4^*}{3}, \frac{+7}{3})$

$(\frac{-1}{3}, \frac{+4^*}{3})$

$(\frac{+5}{3}, \frac{-2}{3})$

$u(\uparrow, \mathrm{G}), \bar{s}(\downarrow, \bar{\mathrm{B}})$ 0

$(\frac{-1}{3}, \frac{+7}{3})$

$(\frac{+2^*}{3}, \frac{+4}{3})$

$(\frac{+8}{3}, \frac{-2^*}{3})$

$d(\uparrow, \mathrm{G}), \bar{u}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-4^*}{3}, \frac{+1^*}{3})$

$(\frac{-1^*}{3}, \frac{-2}{3})$

$(\frac{+5}{3}, \frac{-8}{3})$

$d(\uparrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{G}})$ 0, $u(\uparrow, \mathrm{R}), \bar{u}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-4}{3}, \frac{+4}{3})$, $(\frac{-1^*}{3}, \frac{+1^*}{3})$

$(\frac{-1^*}{3}, \frac{+1^*}{3})$, $(\frac{+2}{3}, \frac{-2}{3})$

$(\frac{+5}{3}, \frac{-5}{3})$, $(\frac{+8}{3}, \frac{-8}{3})$

$u(\uparrow, \mathrm{R}), \bar{d}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{-1^*}{3}, \frac{+4}{3})$

$(\frac{+2}{3}, \frac{+1^*}{3})$

$(\frac{+8}{3}, \frac{-5}{3})$

$s(\uparrow, \mathrm{B}), \bar{u}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{-7}{3}, \frac{+1}{3})$

$(\frac{-4}{3}, \frac{-2^*}{3})$

$(\frac{+2^*}{3}, \frac{-8}{3})$

$s(\uparrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-7}{3}, \frac{+4^*}{3})$

$(\frac{-4^*}{3}, \frac{+1}{3})$

$(\frac{+2}{3}, \frac{-5}{3})$

Figure 19.1: $q(\uparrow, \alpha), \bar{q}(\downarrow, \bar{\beta})$ of colored mesons

OR

$d(\uparrow, \mathrm{R}), \bar{s}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{-4}{3}, \frac{+4}{3})$

$u(\uparrow, \mathrm{G}), \bar{s}(\downarrow, \bar{\mathrm{B}})$ 0

$(\frac{+2}{3}, \frac{-2}{3})$

$d(\uparrow, \mathrm{G}), \bar{u}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-1}{3}, \frac{+1}{3})$

$d(\uparrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{G}})$ 0, $u(\uparrow, \mathrm{R}), \bar{u}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-1}{3}, \frac{+1}{3})$, $(\frac{-1}{3}, \frac{+1}{3})$

$u(\uparrow, \mathrm{R}), \bar{d}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{-1}{3}, \frac{+1}{3})$

$s(\uparrow, \mathrm{B}), \bar{u}(\downarrow, \bar{\mathrm{G}})$ 0

$(\frac{+2}{3}, \frac{-2}{3})$

$s(\uparrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{R}})$ 0

$(\frac{-4}{3}, \frac{+4}{3})$

Figure 19.2: $\mathrm{S}_3(q(\uparrow, \alpha), \bar{q}(\downarrow, \bar{\beta})) \equiv \mathrm{S}_3(\uparrow, \downarrow)$ of colored mesons

$$d(\downarrow, \mathrm{R}), \bar{s}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-7^*}{3}, \tfrac{+10}{3}\right)$$
$$\left(\tfrac{-4}{3}, \tfrac{+7^*}{3}\right)$$
$$\left(\tfrac{+2}{3}, \tfrac{+1}{3}\right)$$

$$u(\downarrow, \mathrm{G}), \bar{s}(\uparrow, \overline{\mathrm{B}})\ \ 0$$
$$\left(\tfrac{-4}{3}, \tfrac{+10}{3}\right)$$
$$\left(\tfrac{-1^*}{3}, \tfrac{+7}{3}\right)$$
$$\left(\tfrac{+5}{3}, \tfrac{+1^*}{3}\right)$$

$$d(\downarrow, \mathrm{G}), \bar{u}(\uparrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-7^*}{3}, \tfrac{+4^*}{3}\right)$$
$$\left(\tfrac{-4^*}{3}, \tfrac{+1}{3}\right)$$
$$\left(\tfrac{+2}{3}, \tfrac{-5}{3}\right)$$

$$d(\downarrow, \mathrm{R}), \bar{d}(\uparrow, \overline{\mathrm{R}})\ \ 0,\ u(\downarrow, \mathrm{R}), \bar{u}(\uparrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-7}{3}, \tfrac{+7}{3}\right),\ \left(\tfrac{-4^*}{3}, \tfrac{+4^*}{3}\right)$$
$$\left(\tfrac{-4^*}{3}, \tfrac{+4^*}{3}\right),\ \left(\tfrac{-1}{3}, \tfrac{+1}{3}\right)$$
$$\left(\tfrac{+2}{3}, \tfrac{-2}{3}\right),\ \left(\tfrac{+5}{3}, \tfrac{-5}{3}\right)$$

$$u(\downarrow, \mathrm{R}), \bar{d}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-4^*}{3}, \tfrac{+7}{3}\right)$$
$$\left(\tfrac{-1}{3}, \tfrac{+4^*}{3}\right)$$
$$\left(\tfrac{+5}{3}, \tfrac{-2}{3}\right)$$

$$s(\downarrow, \mathrm{B}), \bar{u}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-10}{3}, \tfrac{+4}{3}\right)$$
$$\left(\tfrac{-7}{3}, \tfrac{+1^*}{3}\right)$$
$$\left(\tfrac{-1^*}{3}, \tfrac{-5}{3}\right)$$

$$s(\downarrow, \mathrm{G}), \bar{d}(\uparrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-10}{3}, \tfrac{+7^*}{3}\right)$$
$$\left(\tfrac{-7^*}{3}, \tfrac{+4}{3}\right)$$
$$\left(\tfrac{-1}{3}, \tfrac{-2}{3}\right)$$

Figure 20.1: $q(\downarrow, \alpha), \bar{q}(\uparrow, \bar{\beta})$ of colored meson

OR

$$d(\downarrow, \mathrm{R}), \bar{s}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-7}{3}, \tfrac{+7}{3}\right)$$

$$u(\downarrow, \mathrm{G}), \bar{s}(\uparrow, \overline{\mathrm{B}})\ \ 0$$
$$\left(\tfrac{-1}{3}, \tfrac{+1}{3}\right)$$

$$d(\downarrow, \mathrm{G}), \bar{u}(\uparrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-4}{3}, \tfrac{=4}{3}\right)$$

$$d(\uparrow, \mathrm{G}), \bar{d}(\downarrow, \overline{\mathrm{G}})\ \ 0,\ u(\uparrow, \mathrm{R}), \bar{u}(\downarrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-4^*}{3}, \tfrac{+4^*}{3}\right),\ \left(\tfrac{-4^*}{3}, \tfrac{+4^*}{3}\right)$$

$$u(\downarrow, \mathrm{R}), \bar{d}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-4}{3}, \tfrac{+4}{3}\right)$$

$$s(\downarrow, \mathrm{B}), \bar{u}(\uparrow, \overline{\mathrm{G}})\ \ 0$$
$$\left(\tfrac{-1}{3}, \tfrac{+1}{3}\right)$$

$$s(\downarrow, \mathrm{G}), \bar{d}(\uparrow, \overline{\mathrm{R}})\ \ 0$$
$$\left(\tfrac{-7}{3}, \tfrac{+7}{3}\right)$$

Figure 20.2: $\mathrm{S}_3(q(\downarrow, \alpha), \bar{q}(\uparrow, \bar{\beta})) \equiv \mathrm{S}_3(\downarrow, \uparrow)$ of colored mesons

《**B2**》 The spin angular momentum directions, between quark $q(\chi)$ and antiquark $\bar{q}(\chi)$, are parallel:

$d(\uparrow,\mathrm{R}),\bar{s}(\uparrow,\overline{\mathrm{G}})$ +1

$(\frac{-4*}{3},\frac{+10}{3})$
$(\frac{-1}{3},\frac{+7*}{3})$
$(\frac{+5}{3},\frac{+1}{3})$

$u(\uparrow,\mathrm{G}),\bar{s}(\uparrow,\overline{\mathrm{B}})$ +1

$(\frac{-1}{3},\frac{+10}{3})$
$(\frac{+2*}{3},\frac{+7}{3})$
$(\frac{+8}{3},\frac{+1*}{3})$

$d(\uparrow,\mathrm{G}),\bar{u}(\uparrow,\overline{\mathrm{R}})$ +1

$(\frac{-4}{3},\frac{+4*}{3})$
$(\frac{-1*}{3},\frac{+1}{3})$
$(\frac{+5}{3},\frac{-5}{3})$

$d(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ +1, $u(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ +1

$(\frac{-4}{3},\frac{+7}{3})*$, $(\frac{-1}{3},\frac{+4}{3})*$
$(\frac{-1}{3},\frac{+4}{3})*$, $(\frac{+2}{3},\frac{+1}{3})*$
$(\frac{+5}{3},\frac{-2}{3})*$, $(\frac{+8}{3},\frac{-5}{3})*$

$u(\uparrow,\mathrm{R}),\bar{d}(\uparrow,\overline{\mathrm{G}})$ +1

$(\frac{-1*}{3},\frac{+7}{3})$
$(\frac{+2}{3},\frac{+4*}{3})$
$(\frac{+8}{3},\frac{-2}{3})$

$s(\uparrow,\mathrm{B}),\bar{u}(\uparrow,\overline{\mathrm{G}})$ +1

$(\frac{-7}{3},\frac{+4}{3})$
$(\frac{-4}{3},\frac{+1*}{3})$
$(\frac{+2*}{3},\frac{-5}{3})$

$s(\uparrow,\mathrm{G}),\bar{d}(\uparrow,\overline{\mathrm{R}})$ +1

$(\frac{-7}{3},\frac{+7*}{3})$
$(\frac{-4*}{3},\frac{+4}{3})$
$(\frac{+2}{3},\frac{-2}{3})$

Figure 21.1: $q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})$ of colored mesons

OR

$d(\uparrow,\mathrm{R}),\bar{s}(\uparrow,\overline{\mathrm{G}}))$ +1/2

$(\frac{-4}{3},\frac{+7}{3})$

$u(\uparrow,\mathrm{G}),\bar{s}(\uparrow,\overline{\mathrm{B}})$ +1/2

$(\frac{+2}{3},\frac{+1}{3})$

$d(\uparrow,\mathrm{G}),\bar{u}(\uparrow,\overline{\mathrm{R}})$ +1/2

$(\frac{-1}{3},\frac{+4}{3})$

$d(\uparrow,\alpha),\bar{d}(\uparrow,\bar{\alpha})$ +1/2, $u(\uparrow,\alpha),\bar{u}(\uparrow,\bar{\alpha})$ +12

$(\frac{-4}{3},\frac{+7}{3})$, $(\frac{+2}{3},\frac{+1}{3})$

$u(\uparrow,\mathrm{R}),\bar{d}(\uparrow,\overline{\mathrm{G}})$ +1/2

$(\frac{-1}{3},\frac{+4}{3})$

$s(\uparrow,\mathrm{B}),\bar{u}(\uparrow,\overline{\mathrm{G}})$ +1/2

$(\frac{+2}{3},\frac{+1}{3})$

$s(\uparrow,\mathrm{G}),\bar{d}(\uparrow,\overline{\mathrm{R}})$ +1/2

$(\frac{-4}{3},\frac{+7}{3})$

Figure 21.2: $\mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta}))\equiv\mathrm{S}_3(\uparrow,\uparrow)$ of colored mesons

$d(\downarrow, \mathrm{R}), \bar{s}(\downarrow, \bar{\mathrm{G}})\ -1$

$$\left(\frac{-7^*}{3}, \frac{+7}{3}\right) \quad \left(\frac{-4}{3}, \frac{+4^*}{3}\right) \quad \left(\frac{+2}{3}, \frac{-2}{3}\right)$$

$u(\downarrow, \mathrm{G}), \bar{s}(\downarrow, \bar{\mathrm{B}})\ -1$

$$\left(\frac{-4}{3}, \frac{+7}{3}\right) \quad \left(\frac{-1^*}{3}, \frac{+4}{3}\right) \quad \left(\frac{+5}{3}, \frac{-2^*}{3}\right)$$

$d(\downarrow, \mathrm{G}), \bar{u}(\downarrow, \bar{\mathrm{R}})\ -1$

$$\left(\frac{-7}{3}, \frac{+1^*}{3}\right) \quad \left(\frac{-4^*}{3}, \frac{-2}{3}\right) \quad \left(\frac{+2}{3}, \frac{-8}{3}\right)$$

$d(\uparrow, \alpha), \bar{d}(\downarrow, \bar{\alpha})\ -1,\ u(\downarrow, \alpha), \bar{u}(\downarrow, \bar{\alpha})\ -1$

$$\left(\frac{-7}{3}, \frac{+4}{3}\right)^*, \left(\frac{-4}{3}, \frac{+1}{3}\right)^*$$
$$\left(\frac{-4}{3}, \frac{+1}{3}\right)^*, \left(\frac{-1}{3}, \frac{-2}{3}\right)^*$$
$$\left(\frac{+2}{3}, \frac{-5}{3}\right)^*, \left(\frac{+5}{3}, \frac{-8}{3}\right)^*$$

$u(\downarrow, \mathrm{R}), \bar{d}(\downarrow, \bar{\mathrm{G}})\ -1$

$$\left(\frac{-4^*}{3}, \frac{+4}{3}\right) \quad \left(\frac{-1}{3}, \frac{+1^*}{3}\right) \quad \left(\frac{+5}{3}, \frac{-5}{3}\right)$$

$s(\downarrow, \mathrm{B}), \bar{u}(\downarrow, \bar{\mathrm{G}})\ -1$

$$\left(\frac{-10}{3}, \frac{+1}{3}\right) \quad \left(\frac{-7}{3}, \frac{-2^*}{3}\right) \quad \left(\frac{-1^*}{3}, \frac{-8}{3}\right)$$

$s(\downarrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{R}})\ -1$

$$\left(\frac{-10}{3}, \frac{+4^*}{3}\right) \quad \left(\frac{-7^*}{3}, \frac{+1}{3}\right) \quad \left(\frac{-1}{3}, \frac{-5}{3}\right)$$

Figure 22.1: $q(\downarrow, \alpha), \bar{q}(\downarrow, \bar{\beta})$ of colored mesons

OR

$d(\downarrow, \mathrm{R}), \bar{s}(\downarrow, \bar{\mathrm{G}})\ -1/2$

$$\left(\frac{-7}{3}, \frac{+4}{3}\right)$$

$u(\uparrow, \mathrm{G}), \bar{s}(\uparrow, \bar{\mathrm{B}})\ -1/2$

$$\left(\frac{-1}{3}, \frac{-2}{3}\right)$$

$d(\downarrow, \mathrm{G}), \bar{u}(\downarrow, \bar{\mathrm{R}})\ -1/2$

$$\left(\frac{-4}{3}, \frac{-1}{3}\right)$$

$d(\downarrow, \alpha), \bar{d}(\downarrow, \bar{\alpha})\ -1/2,\ u(\downarrow, \alpha), \bar{u}(\downarrow, \bar{\alpha})\ -1/2$

$$\left(\frac{-7}{3}, \frac{+4}{3}\right), \left(\frac{-1}{3}, \frac{-2}{3}\right)$$

$u(\downarrow, \mathrm{R}), \bar{d}(\downarrow, \bar{\mathrm{G}})\ -1/2$

$$\left(\frac{-4}{3}, \frac{+1}{3}\right)$$

$s(\downarrow, \mathrm{B}), \bar{u}(\downarrow, \bar{\mathrm{G}})\ -1/2$

$$\left(\frac{-1}{3}, \frac{-2}{3}\right)$$

$s(\downarrow, \mathrm{G}), \bar{d}(\downarrow, \bar{\mathrm{R}})\ -1/2$

$$\left(\frac{-7}{3}, \frac{+4}{3}\right)$$

Figure 22.2: $\mathrm{S}_3(q(\downarrow, \alpha), \bar{q}(\downarrow, \bar{\beta})) \equiv \mathrm{S}_3(\downarrow, \downarrow)$ of colored mesons

Summary 《**B**》 $\alpha \neq \beta$

$$\begin{array}{ccccc} & & q\bar{q} & & \\ & R\bar{G} & & G\bar{B} & \\ G\bar{R} & & \alpha\bar{\alpha} & & R\bar{G} \\ & B\bar{G} & & G\bar{R} & \end{array} = \begin{array}{ccccc} & & q\bar{q} & & \\ & +1/2 & & +1/2 & \\ +1/2 & & +1/2 & & +1/2 \\ & +1/2 & & +1/2 & \end{array} , \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & 0 & \\ 0 & & 0 & & 0 \\ & 0 & & 0 & \end{array} , \begin{array}{ccccc} & & q\bar{q} & & \\ & -1/2 & & -1/2 & \\ -1/2 & & -1/2 & & -1/2 \\ & -1/2 & & -1/2 & \end{array}$$

$S_3(q(\chi,\alpha),\bar{q}(\chi,\bar{\beta}) \;=$ Figure.21.3 $S_3(\uparrow,\uparrow)$ Figure.19.3 $S_3(\uparrow,\downarrow)$, Figure.20.3 $S_3(\downarrow,\uparrow)$, Figure.22.3 $S_3(\downarrow,\downarrow)$

$$\tfrac{1}{2}\left\{ S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})) + S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta})) \right\}$$

$$= \tfrac{1}{2}\left\{ \begin{array}{ccccc} & & q\bar{q} & & \\ & +1/2 & & +1/2 & \\ +1/2 & & +1/2 & & +1/2 \\ & +1/2 & & +1/2 & \end{array} + \begin{array}{ccccc} & & q\bar{q} & & \\ & -1/2 & & -1/2 & \\ -1/2 & & -1/2 & & -1/2 \\ & -1/2 & & -1/2 & \end{array} \right\} = \tfrac{1}{2} \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & 0 & \\ 0 & & 0 & & 0 \\ & 0 & & 0 & \end{array} = \begin{array}{ccccc} & & q\bar{q} & & \\ & 0 & & 0 & \\ 0 & & 0 & & 0 \\ & 0 & & 0 & \end{array}$$

$$= S_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\beta}) = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta}) \qquad (19)$$

$$\tfrac{1}{2}\left\{ S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta})) - S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta})) \right\}$$

$$= \tfrac{1}{2}\left\{ \begin{array}{ccccc} & & q\bar{q} & & \\ & +1/2 & & +1/2 & \\ +1/2 & & +1/2 & & +1/2 \\ & +1/2 & & +1/2 & \end{array} - \begin{array}{ccccc} & & q\bar{q} & & \\ & -1/2 & & -1/2 & \\ -1/2 & & -1/2 & & -1/2 \\ & -1/2 & & -1/2 & \end{array} \right\} = \tfrac{1}{2} \begin{array}{ccccc} & +1 & & +1 & \\ +1 & & +1 & & +1 \\ & +1 & & +1 & \end{array} = \begin{array}{ccccc} & +1/2 & & +1/2 & \\ +1/2 & & +1/2 & & +1/2 \\ & +1/2 & & +1/2 & \end{array} \qquad (20)$$

$$S_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\beta}) = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta}) \qquad (21)$$

$$S_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\alpha})) - 1/2 = S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta}))\ ,\ S_3(q(\downarrow,\alpha),\bar{q}(\uparrow,\bar{\beta})) = S_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta})) + 1/2 \qquad (22)$$

13. Gluon Color gg_{color} Associated with Meson $gg_{color}(q\bar{q}) = g(q\bar{q})_{color}$

Because *gluon corlor* $g_{\alpha\beta}$ (7) (part.B) is related to quark color q_α and antiquark color $\bar{q}_\beta$, mesons are comprised of a quark and an antiquark, further in when discussing cloreed mesons, we introduce gluon color gg_{color} (similar to ggg_{color} in discussing baryons section.8 previously), gg_{color} is an array that comprises two matrix elements that listed in subtables of Table.5 αβM.

abbrevation $g(q\bar{q})_{\text{color}} \equiv gg_{\text{color}}(q\bar{q}_{\text{color}})$: while gg_{color} associated with meson $q\bar{q}_{\text{color}}$

Next, three examples of $g(q\bar{q})_{\text{color}}$, 1), 2) and 3), base on using Table.5 gluon color matrix αβM, are given below.

We see: in case 1) and 2), the arithmetic sum of two matrix elements in the array $g(q\bar{q})_{\text{color}}$ are all zero, but the square sum of their are variations on color seclection of quark q and antiquark q^-

1) the example of gg_{color} associated with meson $u\bar{u}$, we get $g(u\bar{u})_{\text{color}}$

$$\begin{matrix} g(u\bar{u})_{\text{color}} \\ (u\bar{u}, u\bar{u}) \\ (R\bar{R}, R\bar{R}) \end{matrix} = \begin{matrix} g(u\bar{u})_{\text{color}}\ 0 \\ (1,\ 1) \\ (0,\ 0) \end{matrix} \Leftrightarrow g(u\bar{u})_{\text{color}} = (0,\ 0); \Rightarrow \begin{matrix} g(u\bar{u})_{\text{color}} \\ \text{arithmetic sum } (0) + (0) = 0 \\ \text{square sum } (0)^2 + (0)^2 = 0 \end{matrix} \quad (23.1)$$

$$\begin{matrix} g(u\bar{u})_{\text{color}} \\ (u\bar{u}, u\bar{u}) \\ (R\bar{G}, G\bar{R}) \end{matrix} = \begin{matrix} g(u\bar{u})_{\text{color}}\ 0 \\ (4,\ 5) \\ (-1,\ +1) \end{matrix} \Leftrightarrow g(u\bar{u})_{\text{color}} = (-1,\ +1); \Rightarrow \begin{matrix} g(u\bar{u})_{\text{color}} \\ \text{arithmetic sum } (-1) + (+1) = 0 \\ \text{square sum } (-1)^2 + (+1)^2 = +2 \end{matrix} \quad (23.2)$$

$$\begin{matrix} g(u\bar{u})_{\text{color}} \\ (u\bar{u}, u\bar{u}) \\ (R\bar{B}, B\bar{R}) \end{matrix} = \begin{matrix} g(u\bar{u})_{\text{color}}\ 0 \\ (9,\ 8) \\ (-3,\ +3) \end{matrix} \Leftrightarrow g(u\bar{u})_{\text{color}} = (-3,\ +3); \Rightarrow \begin{matrix} g(u\bar{u})_{\text{color}} \\ \text{arithmetic sum } (-3) + (+3) = 0 \\ \text{square sum } (-3)^2 + (+3)^2 = +18 \end{matrix} \quad (23.3)$$

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2) the example of gg_{color} associated with meson $u\bar{d}$, we get $g(u\bar{d})_{\text{color}}$

$$\begin{array}{ccc} g(u\bar{d})_{\text{color}} & & g(u\bar{d})_{\text{color}}\ \ 0 \\ (\,u\bar{d},\, d\bar{u}\,) & = & (\ 1,\ \ 1\ ) \\ (\,\text{R}\bar{\text{R}},\, \text{R}\bar{\text{R}}\,) & & (\,+1,\ -1\,) \end{array} \Leftrightarrow g(u\bar{d})_{\text{color}} = (\,+1,\ -1\,); \Rightarrow \begin{array}{c} g(u\bar{d})_{\text{color}} \\ \text{arithmetic sum } (+1) + (-1) = 0 \\ \text{square sum } (+1)^2 + (-1)^2 = +2 \end{array} \qquad (24.1)$$

$$\begin{array}{ccc} g(u\bar{d})_{\text{color}} & & g(u\bar{d})_{\text{color}}\ \ 0 \\ (\,u\bar{d},\, d\bar{u}\,) & = & (\ 4,\ \ 5\ ) \\ (\,\text{R}\bar{\text{G}},\, \text{G}\bar{\text{R}}\,) & & (\ 0,\ \ 0\ ) \end{array} \Leftrightarrow g(u\bar{d})_{\text{color}} = (\ 0,\ \ 0\ ); \Rightarrow \begin{array}{c} g(u\bar{d})_{\text{color}} \\ \text{arithmetic sum } (0) + (0) = 0 \\ \text{square sum } (0)^2 + (0)^2 = 0 \end{array} \qquad (24.2)$$

$$\begin{array}{ccc} g(u\bar{d})_{\text{color}} & & g(u\bar{d})_{\text{color}}\ \ 0 \\ (\,u\bar{d},\, d\bar{u}\,) & = & (\ 9,\ \ 8\ ) \\ (\,\text{R}\bar{\text{B}},\, \text{B}\bar{\text{R}}\,) & & (\,-2,\ +2\,) \end{array} \Leftrightarrow g(u\bar{d})_{\text{color}} = (\,-2,\ +2\,); \Rightarrow \begin{array}{c} g(u\bar{d})_{\text{color}} \\ \text{arithmetic sum } (-2) + (+2) = 0 \\ \text{square sum } (-2)^2 + (+2)^2 = +8 \end{array} \qquad (24.3)$$

3), both arithmetic sum and square sum of two matrix elements in the array $g(q\bar{q})_{\text{color}}$ are not zero.

$$\begin{array}{ccc} g(u\bar{d})_{\text{color}} & & g(u\bar{d})_{\text{color}}\ \ -1 \\ (u\bar{d}),\ (d\bar{u}) & = & (\ 4,\ \ 3\ ) \\ (\text{R}\bar{\text{G}},\ \ \text{B}\bar{\text{B}}) & & (0,\ \ -1) \end{array} \Leftrightarrow g(u\bar{d})_{\text{color}} = (0,\ \ -1); \Rightarrow \begin{array}{c} g(u\bar{d})_{\text{color}} \\ \text{arithmetic sum } (0) + (-1) = -1 \neq 0 \\ \text{square sum } (0)^2 + (-1)^2 = +1 \neq 0 \end{array} \qquad (25.1)$$

$$\begin{array}{ccc} g(u\bar{d})_{\text{color}} & & g(u\bar{d})_{\text{color}}\ \ +1 \\ (u\bar{d}),\ (d\bar{u}) & = & (\ 5,\ \ 3\ ) \\ (\text{G}\bar{\text{R}},\ \ \text{B}\bar{\text{B}}) & & (+2,\ \ -1) \end{array} \Leftrightarrow g(u\bar{d})_{\text{color}} = (+2,\ \ -1); \Rightarrow \begin{array}{c} g(u\bar{d})_{\text{color}} \\ \text{arithmetic sum } (+2) + (-1) = +1 \neq 0 \\ \text{square sum } (-2)^2 + (-1)^2 = +5 \neq 0 \end{array} \qquad (25.2)$$

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14. Corlor Ground State, $g\,(q\bar{q})_{\text{COLOR}} = (0, 0)$ and Color Excited State $g\,(q\bar{q})_{\text{COLOR}} \neq (0, 0)$ of Gluon Nonet

Formula $g(u\bar{u}, 0)_{\text{color}} = (0,\ 0)$ (23.1) and formula $g(u\bar{d}, 0)_{\text{color}} = (0,\ \ 0)$ (24.2) are named as ground states of $g(u\bar{u})_{\text{color}}$ and that of $g(u\bar{d})_{\text{color}}$ respectively, due to the square sums of (23.1) and (24.2) are minimums.

Formula $g(u\bar{u}, 0)_{\text{color}} = (0,\ -1)$ (25.1) and $g(u\bar{d}, 0)_{\text{color}} = (+2,\ -1)$ (25.2) are named as excited states of $g(u\bar{d})_{\text{color}}$ and that of $g(u\bar{d})_{\text{color}}$ respectively.

In this way, we are going to discuss corlor ground state, $g(q\bar{q})_{\text{color}} = (0, 0)$ and excited state $g(q\bar{q})_{\text{color}} \neq (0, 0)$, of gluon nonet. First, we collect all matrix elements of $g(q\bar{q}, 0)_{\text{color}} = (0, 0)$ that based on Table.5 to make up Table.8.

⊞ = $R\bar{R}$, $G\bar{G}$, $B\bar{B}$

	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$
t	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$		
c	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$	
u	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$
d	$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$
s		$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$
b			$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞
	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$

Table 8: gluon color ground state $g(q\bar{q}, 0)_{\text{color}}$ rusulted from flovors $r, w\ (t,\ c,\ u,\ d,\ s,\ b)$

Then using this table, it is easy to extend ground states $g(u\bar{u}, 0)_{\text{color}}$ (23.1) and $g(u\bar{d}, 0)_{\text{color}}$ (24.2) to corlor ground state of colored gluon nonet Table.9.1 below. And extend $g(u\bar{d})_{\text{color}}$ (25.2) to corlor excited state of colored gluon nonet Table.10.1 below

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$g(d\bar{s},0)_{\text{color}}\ 0$
$(d\bar{s}),(s\bar{d})$
$(R\bar{G},\ G\bar{R})$
$(0,\ 0)$

$g(u\bar{s},0)_{\text{color}}\ 0$
$(u\bar{s}),(s\bar{u})$
$(G\bar{B},\ B\bar{G})$
$(0,\ 0)$

$g(d\bar{u},0)_{\text{color}}\ 0$
$(d\bar{u}),(u\bar{d})$
$(G\bar{R},\ R\bar{G})$
$(0,\ 0)$

$g(d\bar{d},0)_{\text{color}}\ 0,\ g(u\bar{u},0)_{\text{color}}\ 0$
$(d\bar{d}),(d\bar{d}),\ (u\bar{u}),(u\bar{u})$
(⊞, ⊞)
$(0,\ 0)$

$g(u\bar{d},0)_{\text{color}}\ 0$
$(u\bar{d}),(d\bar{u})$
$(R\bar{G},\ G\bar{R})$
$(0,\ 0)$

- Table.9.1 Color Ground state
- of colored gluon nonet
- $g(q\bar{q})_{\text{color}} = (0,\ 0)$

$g(s\bar{u},0)_{\text{color}}\ 0$
$(s\bar{u}),(u\bar{s})$
$(B\bar{G},\ G\bar{B})$
$(0,\ 0)$

$g(s\bar{d},0)_{\text{color}}\ 0$
$(s\bar{d}),(d\bar{s})$
$(G\bar{R},\ R\bar{G})$
$(0,\ 0)$

• • • • • • • • • • • • • • • • • • • • • • • • • •

$g(d\bar{s})_{\text{color}}\ +1$
$(d\bar{s}),(s\bar{d})$
$(G\bar{R},\ B\bar{B})$
$(+2,\ -1)$

$g(u\bar{s})_{\text{color}}\ +2$
$(u\bar{s}),(s\bar{u})$
$(B\bar{G},\ R\bar{R})$
$(+4,\ -2)$

$g(d\bar{u})_{\text{color}}\ -1$
$(d\bar{u}),(u\bar{d})$
$(R\bar{G},\ B\bar{B})$
$(-2,\ +1)$

$g(d\bar{d})_{\text{color}}\ 0,\ \ g(u\bar{u})_{\text{color}}\ 0$
$(d\bar{d}),(d\bar{d}),\ (u\bar{u}),(u\bar{u})$
(⊞, ⊞)
$(0,\ 0)$

$g(u\bar{d})_{\text{color}}\ +1$
$(u\bar{d}),(d\bar{u})$
$(G\bar{R},\ B\bar{B})$
$(+2,\ -1)$

- Table.10.1. Color Excited state
- of colored gluon nonet
- $g(q\bar{q})_{\text{color}} \neq (0,\ 0)$

$g(s\bar{u})_{\text{color}}\ -2$
$(s\bar{u}),(u\bar{s})$
$(G\bar{B},\ R\bar{R})$
$(-4,\ +2)$

$g(s\bar{d})_{\text{color}}\ -1$
$(s\bar{d}),(d\bar{s})$
$(R\bar{G},\ B\bar{B})$
$(-2,\ +1)$

$S_3(g(d\bar{s}, 0)_{color})$
$(d\bar{s}), (s\bar{d})$
$(R\bar{G},\ G\bar{R})$
0

$S_3(g(u\bar{s}, 0)_{color})$
$(u\bar{s}), (s\bar{u})$
$(G\bar{B},\ B\bar{G})$
(0, 0)

$S_3(g(d\bar{u}, 0)_{color})$
$(d\bar{u}), (u\bar{d})$
$(G\bar{R},\ R\bar{G})$
0

$S_3(g(d\bar{d}, 0)_{color}),\ S_3(g(u\bar{u}, 0)_{color})$
$(d\bar{d}), (d\bar{d}),\ (u\bar{u}), (u\bar{u})$
(⊞, ⊞)
0

$S_3(g(u\bar{d}, 0)_{color})$
$(u\bar{d}), (d\bar{u})$
$(R\bar{G},\ G\bar{R})$
0

- Table.9.2 Spin Component S_3
- of Color Ground state
- of colored gluon nonet
- $S_3(g(q\bar{q})_{color}) = S_3(g(q\bar{q}, 0)_{color})$

$S_3(g(s\bar{u}, 0)_{color})$
$(s\bar{u}), (u\bar{s})$
$(B\bar{G},\ G\bar{B})$
0

$S_3(g(s\bar{d}, 0)_{color})$
$(s\bar{d}), (d\bar{s})$
$(G\bar{R},\ R\bar{G})$
0

• • • • • • • • • • • • • • • • • • • • • • • • • •

$S_3(g(d\bar{s})_{color})$
$(d\bar{s}), (s\bar{d})$
$(G\bar{R},\ B\bar{B})$
+1/2

$S_3(g(u\bar{s})_{color})$
$(u\bar{s}), (s\bar{u})$
$(B\bar{G},\ R\bar{R})$
+1

$S_3(g(d\bar{u})_{color})$
$(d\bar{u}), (u\bar{d})$
$(R\bar{G},\ B\bar{B})$
–1/2

$S_3(g(d\bar{d})_{color}),\ S_3(g(u\bar{u}, 0)_{color})$
$(d\bar{d}), (d\bar{d}),\ (u\bar{u}), (u\bar{u})$
(⊞, ⊞)
0

$S_3(g(u\bar{d})_{color})$
$(u\bar{d}), (d\bar{u})$
$(G\bar{R},\ B\bar{B})$
+1/2

- Table.10.2 Spin Component S_3
- Color Excited state
- of colored gluon nonet
- $S_3(g(q\bar{q})_{color})$

$S_3(g(s\bar{u})_{color})$
$(s\bar{u}), (u\bar{s})$
$(G\bar{B},\ R\bar{R})$
–1

$S_3(g(s\bar{d})_{color})$
$(s\bar{d}), (d\bar{s})$
$(R\bar{G},\ B\bar{B})$
–1/2

15. Spin of Gluon Nonet

Analogy to section.10 mentioned before, once we used symbol ggg to express spin angular momentum of gluon SU(4) for baryon qqq, here symbol gg is used to indicate spin angular momentum of gluon nonet assciated with meson $q\bar{q}$. And the value of $g\bar{g}$ is expressed by ★1 and ★2 below:

★1 For corlor ground state

$$S_3(gg)_{\star 1} = \begin{array}{ccccc} & +2 & & -1 & \\ +4 & & +3 & & +2 \\ & +5 & & +4 & \end{array}\ , \begin{array}{ccccc} & -1 & & -1 & \\ -1 & & -1 & & -1 \\ & -1 & & -1 & \end{array}\ , \begin{array}{ccccc} & -1 & & -2 & \\ +1 & & 0 & & -1 \\ & +2 & & +1 & \end{array}\ , \begin{array}{ccccc} & -4 & & -5 & \\ -2 & & -3 & & -4 \\ & -1 & & -2 & \end{array} \quad (26)$$

(26.1) (26.2) (26.3) (26.4)

$$S_3(g(q\bar{q})_{\text{color}})_{\star 1} = \begin{array}{ccccc} & 0 & & 0 & \\ 0 & & 0 & & 0 \\ & 0 & & 0 & \end{array}$$

Table.9.2

★2 For corlor excited state

$$S_3(gg)_{\star 2} = \begin{array}{ccccc} & +5/2 & & +2 & \\ +7/2 & & +3 & & +5/2 \\ & +4 & & +7/2 & \end{array}\ , \begin{array}{ccccc} & -3/2 & & -2 & \\ -1/2 & & -1 & & -3/2 \\ & 0 & & -1/2 & \end{array}\ , \begin{array}{ccccc} & -1/2 & & -1 & \\ +1/2 & & 0 & & -1/2 \\ & +1 & & +1/2 & \end{array}\ , \begin{array}{ccccc} & -7/2 & & -4 & \\ -5/2 & & -3 & & -7/2 \\ & -2 & & -5/2 & \end{array} \quad (27)$$

(27.1) (27.2) (27.3) (27.4)

$$S_3(g(q\bar{q})_{\text{color}})_{\star} = \begin{array}{ccccc} & +1/2 & & +1 & \\ -1/2 & & 0 & & +1/2 \\ & -1 & & -1/2 & \end{array}$$

Table.10.2

Substitute ★1 (26), Table.9.2 and ★2 (27), Table.10.2 into (28), obtain spin S_3 of colored gluon that scciated with meson nonet

$$S_3(gg, g(q\bar{q})_{\text{color}})_{\star 1,\star 2} = \frac{1}{2}\{\ S_3(gg)_{\star 1,\star 2} + S_3(g(q\bar{q})_{\text{color}})_{\star 1,\star 2}\ \} \quad (28)$$

16. Observable Experimental Meson

Analogy to formula (11) Part.C for baryon mentioned, here we using (29) for meson. and obtain Table.11 and Table.12 below

$$\mathrm{S}_3(q\bar{q},\ \text{experimental}) = \frac{1}{2}\{\ \mathrm{S}_3(q\bar{q}, q\bar{q}_{\text{color}}) + \mathrm{S}_3(gg, g(q\bar{q})_{\text{color}})\ \} = \frac{1}{2}\{\ \mathrm{S}_3(q(\chi,\alpha), \bar{q}(\chi,\bar{\beta}))_{《A》,《B》} + \mathrm{S}_3(gg, g(q\bar{q})_{\text{color}})_{\bigstar 1,\bigstar 2}\ \} \quad (29)$$

《A》 $\mathrm{S}_{3\,《A》}$ of meson	$\mathrm{S}_3(q\bar{q}, q\bar{q}_{\text{color}})$	||	$\mathrm{S}_3(gg)$	$\mathrm{S}_3(g(q\bar{q},0)_{\text{color}})$	$\mathrm{S}_3(gg, g(q\bar{q},0)_{\text{color}}$ (28)	||	$\mathrm{S}_3(q\bar{q}$, experime.)
1^- Vector meson	+1 +3/2		+2 –1	0 0	+1 –1/2		+1 +1
$\mathrm{S}_3(q(\uparrow,\alpha), \bar{q}(\uparrow,\bar{\alpha}))$	0 +1/2 +1	||	+4 +3 +2	0 0 0	+2 +3/2 +1	||	+1 +1 +1
	–1/2 0		+5 +4	0 0	+5/2 +2		+1 +1
	(17.3)		(26.1)	(9.2)			
Pseudoscalar meson	+1/2 +1/2		–1 –1	0 0	–1/2 –1/2		0 0
$\frac{1}{2}\{\mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))$	+1/2 +1/2 +1/2	||	–1 –1 –1	0 0 0	–1/2 –1/2 –1/2	||	0 0 0
$-\mathrm{S}_3(q(\downarrow,\alpha), \bar{q}(\uparrow,\bar{\alpha}))\}$	+1/2 +1/2		–1 –1	0 0	–1/2 –1/2		0 0
	(19)		(26.2)	(9.2)			
1^- Vector meson	+1/2 +1		–1 –2	0 0	–1/2 –1		0 0
$\frac{1}{2}\{\mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\downarrow,\bar{\alpha}))$	–1/2 0 +1/2	||	+1 0 –1	0 0 0	+1/2 0 –1/2	||	0 0 0
$+\mathrm{S}_3(q(\downarrow,\alpha), \bar{q}(\uparrow,\bar{\alpha}))\}$	–1 –1/2		+2 +1	0 0	+1 +1/2		0 0
	(15.3),(16.3)		(26.3)	(9.2)			
			m				
1^- Vector meson	0 +1/2		–4 –5	0 0	–2 –5/2		–1 –1
$\mathrm{S}_3(q(\downarrow,\alpha), \bar{q}(\downarrow,\bar{\alpha}))$	–1 –1/2 0	||	–2 –3 –4	0 0 0	–1 –3/2 –2	||	–1 –1 –1
	–3/2 –1		–1 –2	0 0	–1/2 –1		–1 –1
	(18.3)		(26.4)	(9.2)			

Table 11: Formation Of Observed Pseudoscalar Mesons, Vector Mesons. (corlor ground state **《A》**)

《B》 S_3 《B》 of meson	$S_3(q\bar{q}, q\bar{q}_{color})$	‖	$S_3(gg)$	$S_3(g(q\bar{q})_{color})$	$S_3(gg, g(q\bar{q})_{color}$ (28)	‖	$S_3(q\bar{q}$, experim.)
Pseudovector meson	+1/2 +1/2		+5/2 +2	+1/2 +1	+3/2 +3/2		+1 +1
$S_3(q(\uparrow, \alpha), \bar{q}(\uparrow, \bar{\alpha}))$	+1/2 +1/2 +1/2	‖	+7/2 +3 +5/2	−1/2 0 +1/2	+3/2 +3/2 +3/2	‖	+1 +1 +1
	+1/2 +1/2		+4 +7/2	−1 −1/2	+3/2 +3/2		+1 +1
	(21.3)		(27.1)	(10.2)			
Scalar meson	+1/2 +1/2		−3/2 −2	+1/2 +1	−1/2 −1/2		0 0
$\frac{1}{2}\{S_3(q(\uparrow, \alpha), \bar{q}(\downarrow, \bar{\alpha}))$	+1/2 +1/2 +1/2	‖	−1/2 −1 −3/2	−1/2 0 +1/2	−1/2 −1/2 −1/2	‖	0 0 0
$-S_3(q(\downarrow, \alpha), \bar{q}(\uparrow, \bar{\alpha}))\}$	+1/2 +1/2		0 −1/2	−1 −1/2	−1/2 −1/2		0 0
	(19)		(27.2)	(10.2)			
Pseudovector meson	0 0		−1/2 −1	+1/2 +1	0 0		0 0
$\frac{1}{2}\{S_3(q(\uparrow, \alpha), \bar{q}(\downarrow, \bar{\alpha}))$	0 0 0	‖	+1/2 0 −1/2	−1/2 0 +1/2	0 0 0	‖	0 0 0
$+S_3(q(\downarrow, \alpha), \bar{q}(\uparrow, \bar{\alpha}))\}$	0 0		+1 +1/2	−1 −1/2	0 0		0 0
	(19.3), (20.3)		(27.3)	(10.2)			
Pseudovector meson	−1/2 −1/2		−7/2 −4	+1/2 +1	−3/2 −3/2		−1 −1
$S_3(q(\downarrow, \alpha), \bar{q}(\downarrow, \bar{\alpha}))$	−1/2 −1/2 −1/2	‖	−5/2 −3 −7/2	−1/2 0 +1/2	−3/2 −3/2 −3/2	‖	−1 −1 −1
	−1/2 −1/2		−2 −5/2	−1 −1/2	−3/2 −3/2		−1 −1
	(22.3)		(27.4)	(10.2)			

Table 12: Formation Of Observed Scalar Mesons, Pseudovector Mesons. (corlor excited state 《**B**》)

Summary of Meson

spin-color state $\mathbb{R}(q\bar{q};\alpha,\bar{\beta}) = \{\ \mathrm{S}_3(q(\uparrow,\alpha),\bar{q}(\uparrow,\bar{\beta}))$ and $\mathrm{S}_3(q(\downarrow,\alpha),\bar{q}(\downarrow,\bar{\beta}))\ \}$ (30)

【S1】

In case of colored meson 《**A**》 $\alpha = \beta$

colored pseudoscalar meson is singlet of spin-color state $\mathbb{R}(q\bar{q};\alpha,\bar{\alpha})$

colored vector meson is triplet of spin-color state $\mathbb{R}(q\bar{q};\alpha,\bar{\alpha})$

In case of colored meson 《**B**》 $\alpha \neq \beta$

colored scalar meson is singlet of spin-color state $\mathbb{R}(q\bar{q};\alpha,\bar{\beta})$

colored pseudovector meson is triplet of spin-color state $\mathbb{R}(q\bar{q};\alpha,\bar{\beta})$

【S2】

For corlor ground state: gluon color $g(q\bar{q})_{\text{color}} = g(q\bar{q},0)_{\text{color}} = (0,0)$ (31)

colored mesons 《**A**》 turns into observed pesudoscalar meson and obvserved vector meson

For corlor excited state: gluon color $g(q\bar{q})_{\text{color}} = g(q\bar{q},\xi)_{\text{color}} = (\xi_1,\xi_2)$ $\xi = \xi_1+\xi_2$ (32)

colored mesons 《**B**》 turns into observed scalar meson and obvserved pseudovector meson

【S3】

Meson composite weight diagram from solely role, quark-antiquark to two roles, quark-antiquark and gluons. Using gluon corlor ground state $(0,0)$ and gluon corlor excited state (ξ_1,ξ_2) to instead of orbital angular momentums $L = 0$ and $L = 1$ of quarks in current theory.

Conclusions

From point of view of color symmtry between $B\bar{R}$, $B\bar{G}$, $G\bar{R}$ and $R\bar{G}$, $G\bar{B}$, $R\bar{B}$ about ⊞, Tabele.8 seems to be a bit off-pecfect, something leaved out. If want to restore symmetric color world, Table.8 sould be extended to Table.13. Then new possible flavors should be put into particle physics. Following is the chart of the possible gluon color ground state $g(q\bar{q}, 0)_{\text{color}}$ rusulted from flovors X_1, X_2, X_3 and Y_1, Y_2, Y_3

	X_3	X_2	X_1	$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$			
t	$B\bar{R}$▲	$B\bar{G}$▲	$G\bar{R}$▲	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$	∘	∘			
c		$B\bar{R}$▲	$B\bar{G}$▲	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$	∘			
u			$B\bar{R}$▲	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$			
d				$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$	$R\bar{B}$▼		
s				∘	$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$	$G\bar{B}$▼	$R\bar{B}$▼	
b				∘	∘	$B\bar{R}$	$B\bar{G}$	$G\bar{R}$	⊞	$R\bar{G}$▼	$G\bar{B}$▼	$R\bar{B}$▼
	$r\bar{w}$											
				$\bar{t}$	$\bar{c}$	$\bar{u}$	$\bar{d}$	$\bar{s}$	$\bar{b}$	Y_1	Y_2	Y_3

⊞ = $R\bar{R}$, $G\bar{G}$, $B\bar{B}$

▲ ⊆ X_1, X_2, X_3

▼ ⊆ Y_1, Y_2, Y_3

Table 13: Possible Gluon Color Ground State $g(q\bar{q}, 0)_{\text{color}}$ rusulted from new possible flavors

Where X_1, X_2, X_3 and Y_1, Y_2, Y_3 are the possible existent flavors, which respectively arranged at the left side and the right side of known six flavors. That is: X_3, X_2, X_1 t, c, u, d, s, b, Y_1, Y_2, Y_3. Symbols ▲ and ▼ indicate new gluon color ground states between t, c, u, d, s, b and X_1, X_2, X_3, Y_1, Y_2, Y_3

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Online ISSN: 2249-460x & Print ISSN: 0975-587X; https://doi.org/10.34257/GJSFRAVOL21IS4PG49 2021–11–16

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Analytical Solution of Bessel Integrals in Electromagnetics

By David Marqués Villarroya

Abstract- The electromagnetic study of cylindrical structures involves the resolution of the wave equation in cylindrical coordinates, whose solutions are the well-known Bessel functions. Many research fields in electromagnetics such as scattering, diffraction and resonators use Bessel functions and they must be integrated in order to apply boundary conditions and orthogonality of basis functions. These integrals are solved many times applying numerical methods, but some of them have analytical solution, which is exact against numerical method that presents limited precision and spends high computational time. In this work, the most important analytical integrals of Bessel functions for electromagnetics are provided. Some of them have been obtained from the literature to perform a review, while others are provided here for the first time.

Keywords: integrals, bessel, electromagnetics.

GJSFR-A Classification: DDC Code: 515 LCC Code: QA401

ANALYTICALSOLUTIONOFBESSELINTEGRALSINELECTROMAGNETICS

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Analytical Solution of Bessel Integrals in Electromagnetics

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Abstract- The electromagnetic study of cylindrical structures involves the resolution of the wave equation in cylindrical coordinates, whose solutions are the well-known Bessel functions. Many research fields in electromagnetics such as scattering, diffraction and resonators use Bessel functions and they must be integrated in order to apply boundary conditions and orthogonality of basis functions. These integrals are solved many times applying numerical methods, but some of them have analytical solution, which is exact against numerical method that presents limited precision and spends high computational time. In this work, the most important analytical integrals of Bessel functions for electromagnetics are provided. Some of them have been obtained from the literature to perform a review, while others are provided here for the first time.

Keywords: integrals, bessel, electromagnetics.

I. Introduction

Bessel functions are the solutions of the differential equation of the wave equation of Helmholtz in cylindrical coordinates [1]:

$$f''(z) + \frac{f'(z)}{z} + \left(k^2 - \frac{m^2}{z^2}\right) f(z) = 0 \tag{1}$$

where k is a constant and m is an integer.

The independent solutions of this equation are the first and the second kind of Bessel functions, $J_m(kz)$ and $Y_m(kz)$, respectively. The second kind of Bessel functions are also called Weber or Neumann functions. Then, the generic solution of the differential equation is a linear combination of the Bessel functions:

$$f(z) = A \cdot J_m(kz) + B \cdot Y_m(kz) \tag{2}$$

where A and B are arbitrary constants, whose value can be obtained by applying boundary conditions.

This differential equation appears in many fields of physics involving electromagnetic fields, vibrations, heat conduction diffraction, scattering, etc. We are going to focus on the electromagnetic applications in this work, but all the results obtained here can be used in other fields as well.

Bessel functions must be integrated in many electromagnetic problems such as scattering and resonators problems. A lot of papers and treatises provide analytical solution of some integrals that involves Bessel functions, like Luke [2], Watson [3], Manring[4] and Kajfez [5]. Nevertheless, it is difficult to find the analytical solution of the most important integrals in electromagnetics grouped together and there are not works that provide the analytical solution of all these integrals since they only provide the integrals involved in its particular problem.

In this paper, the most important integrals that have analytical solution and involves Bessel functions in electromagnetics are provided. Some solutions of these integrals have been obtained from the literature, but others have been obtained for the first time in this paper with an interesting method shown in [6].

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II. Analytical Integrals

From now on, we define functions F and G as linear combination of Bessel functions; α and β are arbitrary constants which are included in the argument of Bessel functions; m and n are integer numbers starting in 0 that indicate the order of the Bessel functions; and z is the independent variable. Derivatives of Bessel functions are defined in this paper as follow [7]:

$$F_m'(\alpha z) = \frac{1}{2}\left(F_{m-1}(\alpha z) - F_{m+1}(\alpha z)\right) \tag{3}$$

The first integrals shown in this paper are the most common in electromagnetics, they appear very often in many problems and have been studied deeply in literature, so we are going to provide the analytical solution and the reference where can be found.

From [1]:

$$I_1 = \int z F_m^2(\alpha z) dz = \frac{z^2}{2}\left(\left(F_m'(\alpha z)\right)^2 + \left(1 - \frac{m^2}{\alpha^2 z^2}\right) F_m^2(\alpha z)\right)$$

From [3]:

$$I_2 = \int \left((\alpha^2 - \beta^2) z - \frac{m^2 - n^2}{z}\right) F_m(\alpha z) G_n(\beta z) dz = z\left(\beta F_m(\alpha z) G_n'(\beta z) - \alpha F_m'(\alpha z) G_n(\beta z)\right) \tag{4}$$

From [2]:

$$I_3 = \int z F_m(\alpha z) G_m(\beta z) dz = \frac{z}{(\alpha^2 - \beta^2)}\left(\beta F_m(\alpha z) G_m'(\beta z) - \alpha F_m'(\alpha z) G_m(\beta z)\right) \tag{5}$$

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$$I_4 = \int \frac{1}{z} F_m(\alpha z) G_n(\alpha z) dz = \frac{z\alpha}{n^2-m^2}\left(F_m(\alpha z) G_n'(\alpha z) - F_m'(\alpha z) G_n(\alpha z)\right) \quad (6)$$

$$I_5 = \int z F_m(\alpha z) G_m(\alpha z) dz = \frac{z^2}{2}\left(F_m'(\alpha z) G_m'(\alpha z) + \left(1-\frac{m^2}{\alpha^2 z^2}\right) F_m(\alpha z) G_m(\alpha z)\right) \quad (7)$$

The following integrals are more complex and they appear in specific electromagnetic problems when orthogonality between transversal electric fields (TE) and transversal magnetic fields (TM) is applied in circular waveguides. These integrals are not provided in the classical treatises of Bessel functions like Korenev [1], Watson [3]or Luke [2], but if you look forward deeply in literature, the analytical solution of these integrals can be found as well in specific works.

From [4]:

$$I_6 = \int \left(F_m'(\alpha z) G_m'(\beta z) + \frac{m^2}{\alpha\beta z^2} F_m(\alpha z) G_m(\beta z)\right) z dz = \frac{z}{\alpha^2-\beta^2}\left(\alpha F_m(\alpha z) G_m'(\beta z) - \beta F_m'(\alpha z) G_m(\beta z)\right) \quad (8)$$

From [5]:

$$I_7 = \int \left(\left(F_m'(\alpha z)\right)^2 + \frac{m^2}{\alpha^2 z^2} F_m^2(\alpha z)\right) z dz = \frac{z^2}{2}\left(\left(F_m'(\alpha z)\right)^2 + \left(1-\frac{m^2}{\alpha^2 z^2}\right)\cdot F_m^2(\alpha z) + \frac{2}{\alpha z} F_m'(\alpha z)\cdot F_m(\alpha z)\right) \quad (9)$$

Finally, in the following lines, we provide the analytical solution of two integrals that are not given in any treatise of Bessel functions nor literature about the topic and they appears in electromagnetic problems.

The first one (I_8) appears in cylindrical structures when the mutual influence between TE and TM modes are considered to give place to hybrid modes. This integral can be solved immediately applying the definition of the derivate of the product of two functions and finding the primitive of the integral. This integral that looks very simple to solve analytically is calculated by numerical methods in someworks, loosing accuracy and computational time for their simulations. In this work the analytical solutionis provided:

$$I_8 = \int m\left(\alpha F_m'(\alpha z) G_m(\beta z) + \beta G_m'(\beta z) F_m(\alpha z)\right) dz = m F_m(\alpha z) G_m(\beta z) \quad (10)$$

The second integral (I_9) is also not given in classical treatises and it is more complex to solve. It appears when the stored electromagnetic energy of circular waveguides is calculated. The analytical solution can be obtained with an interesting method described in [6], which get analytical solutions of some integrals starting from the initial differential equation in cylindrical coordinates. The procedure described in [6] is not the main objective of this paper but can be interesting for the reader knows the source to check the procedure and the steps that we have follow to solve this integral. Then, this integral (I_9) is obtained applying this method and the solution is:

$$I_9 = \int \left(\left(F_m'(\alpha z) G_m'(\alpha z)\right)^2 + \frac{m^2}{\alpha^2 z^2} F_m(\alpha z) G_m(\alpha z)\right) z dz = \frac{z}{2\alpha}\left(F_m(\alpha z) G_m'(\alpha z) + F_m'(\alpha z) G_m(\alpha z)\right) + \frac{z^2}{2}\left(F_m'(\alpha z) G_m'(\alpha z) + \left(1-\frac{m^2}{\alpha^2 z^2}\right) F_m(\alpha z) G_m(\alpha z)\right) \quad (11)$$

III. Checking Integrals

In this section, the provided analytical solutions of the integrals shown above are verified comparing the result with numerical methods.

We have chosen a general linear combination of Bessel functions for *F* and *G*as follows:

$$F_m(\alpha z) = A\cdot J_m(\alpha z) + B\cdot Y_m(\alpha z)$$
$$G_n(\beta z) = C\cdot J_m(\beta z) + D\cdot Y_m(\beta z) \quad (12)$$

In addition, we have chosen arbitrary numbers for the constants involved, concretely: $m=1$; $n=2$; $\alpha=10$; $\beta=15$; $A=2$; $B=1.5$; $C=4$; $D=-3$. The integrals have been evaluated from $a=2$ to $b=8$.

With these data, table I shows the relative error between analytical and numerical solution and the time variation between them. The simulations have been performed with MATLAB version 7.10.0 in PC with Intel(R)Core(TM) i7-10750H CPU @ 2.60GHz 2.59 GHz and RAM 16 GB. The numerical method used in function *integral. m* from MATLAB approximates the integral of a function over an interval using global adaptive quadrature and default error tolerances.

Table I: Computation of the integrals. Relative error between numerical and analytical solution and time variation

Integral	Relative Error (%) $\frac{\lvert \text{Num. solution} - \text{Analytic. solution} \rvert}{\text{Analytic. solution}} \cdot 100$	Time variation $\frac{t_{\text{numerical}}}{t_{\text{analytic}}}$
I_1	$2 \cdot 10^{-14}$	2,07
I_2	$8 \cdot 10^{-14}$	2,61
I_3	$2 \cdot 10^{-12}$	2,21
I_4	$1{,}2 \cdot 10^{-12}$	2,18
I_5	$2 \cdot 10^{-13}$	2,27
I_6	$2 \cdot 10^{-12}$	3,33
I_7	$1{,}4 \cdot 10^{-11}$	2,27
I_8	$2 \cdot 10^{-12}$	6,8
I_9	$3 \cdot 10^{-15}$	3,34

Table I shows that the accuracy of the integrals provided above is very good and the computational time to calculate the integrals is much longer in numerical methods than directly applying the expressions of analytical solutions provided in this paper.

IV. Conclusions

In this paper the most important integrals that involves Bessel functions in electromagnetics and have analytical solution have been provided. Especially useful can be the analytical integrals shown in this paper for first time (I_8) and (I_9) in addition to the review of the other integrals developed in different works (I_1 to I_7) and difficult to find all of them together.

The accuracy of the analytical integrals solutions has been verified with numerical methods obtaining excellent results as well as the computational time, which has shown in this work that the evaluation of analytical solution is much better, in terms of computational time and accuracy, than compute the integral numerically. These results can be especially useful to improve the accuracy and optimize the computational time of tough iterative electromagnetic simulations which makes thousands of integrals in each step.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

SEM Imaging for Advanced Bio Materials

By Dr. Alla Srivani, Gurram Vasanth & M. Srinivasa Rao

East European Universit

Abstract- Scanning electron microscopy (SEM) is one of the popular methods for imaging the microstructure and morphology of materials. In an SEM, a low-energy electron beam hits the material and scans the surface of the sample. As the beam reaches and enters the material, various interactions occur that result in the emission of photons and electrons from or near the sample surface. To produce an image, the received signal produced by the electron-sample interaction is detected with different types of detectors, depending on the her SEM mode used. There are various his SEM modes for characterization of materials including biomaterials. B. X-ray imaging, secondary electron imaging, backscattered electron imaging, electron channeling, Auger electron microscopy.

Keywords: SEM, bio imaging, bio materials.

GJSFR-A Classification: DDC Code: 578.45 LCC Code: QH324.9.T45

SEMIMAGINGFORADVANCEDBIOMATERIALS

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SEM Imaging for Advanced Bio Materials

Dr. Alla Srivani [α], Gurram Vasanth [σ] & M. Srinivasa Rao [ρ]

Abstract- Scanning electron microscopy (SEM) is one of the popular methods for imaging the microstructure and morphology of materials. In an SEM, a low-energy electron beam hits the material and scans the surface of the sample. As the beam reaches and enters the material, various interactions occur that result in the emission of photons and electrons from or near the sample surface. To produce an image, the received signal produced by the electron-sample interaction is detected with different types of detectors, depending on the her SEM mode used. There are various his SEM modes for characterization of materials including biomaterials. B. X-ray imaging, secondary electron imaging, backscattered electron imaging, electron channeling, Auger electron microscopy.

Keywords: SEM, bio imaging, bio materials.

I. Introduction

Human eye can distinguish between two points in space that are 0.2 mm apart without an additional lens. This distance is called the resolving power or resolution of the eye. A lens or array of lenses (microscope) can be used to extend this distance so that the eye can see points much closer than 0.2 mm. Modern light microscopes have a maximum magnification of about 1000x.

The resolution of a microscope is limited not only by the number and quality of lenses, but also by the wavelength of light used for illumination. Specifically, white light is in the wavelength range of 400 to 700 nano meters (nm), with an average wavelength of 550 nm in this range. This gives a theoretical resolution limit (not visibility) for optical microscopy in white light of about 200–250 nm. The spots in are still distinguishable. The image on the right shows that the two points are so close together that the central points overlap.

Scanning electron microscopy (SEM) is one of the most widely used instrumentation methods for studying and analyzing imaging micro- and nanoparticle characterization of solid objects. One of the reasons SEM is preferred for particle size analysis is its resolution of 10 nm, or 100 Å. Advanced versions of these instruments can achieve resolutions of around 2.5 nm (25 Å) (Goldstein, 2012). The instrument can also be used in conjunction with other related energy dispersive X-ray microanalytical techniques (EDX, EDS, EDAX) to determine the composition or orientation of individual crystals or features.

A tungsten incandescent lamp or a field emission gun is generally used as an electron source. Field emission guns require ultra-high vacuum conditions (10-10 to 10-11 Torr) to keep the tip free of impurities and oxides (Pathak and Thassu, 2016). The electron beam is accelerated by a high voltage system "20 kV", and after passing through an aperture and an electromagnetic lens it is focused. The beam scans the sample surface using scanning coils. After SEM-type generation, an image is generated from the signal from the area of beam-sample interaction. Backscattered electrons and secondary electrons emitted by the sample above the vacuum level are collected by an appropriately positioned detector (Hafner, 2007). Focusing an area at higher magnification levels (>100kX) enhances surface topography analysis of samples with the highest spatial resolution.

SEM is a versatile instrument that can visualize and analyze almost any material. This makes it the perfect “workhorse” for forensic labs. The applications of SEM-EDS are myriad. SEM has typically been applied in conjunction with EDS in forensic research and cases involving paint, GSR, glass, metal, bone, minerals, soil, building materials, dental restorations, pollen, tape, cuts, explosives, etc. rice field.

SEM-EDS is very useful for forensic investigations with its ability to visualize surfaces, position the beam for analysis, and generate elemental and chemical information about heterogeneous constituents of the sample. Some examples show multiple uses for this device. In an attempt to identify bullet wipers from wounds, pork ribs with intact musculature were shot with .45 caliber ammunition from a range of 1 to 6 feet. Unexpectedly, the shot was fired from a distance of 6 feet, and after processing the tissue and bone for viewing in his conventional SEM.

The GSR was found deep within the wound tract within the bone. This finding means that the method may allow analysts to distinguish gun trauma from other confusing types of trauma.

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Table 1

Acceleration Volt Age (Kv)	Spot Size (Nm)	Z Height Distance (Mm)
5	5	8
10	10	10
15	15	20

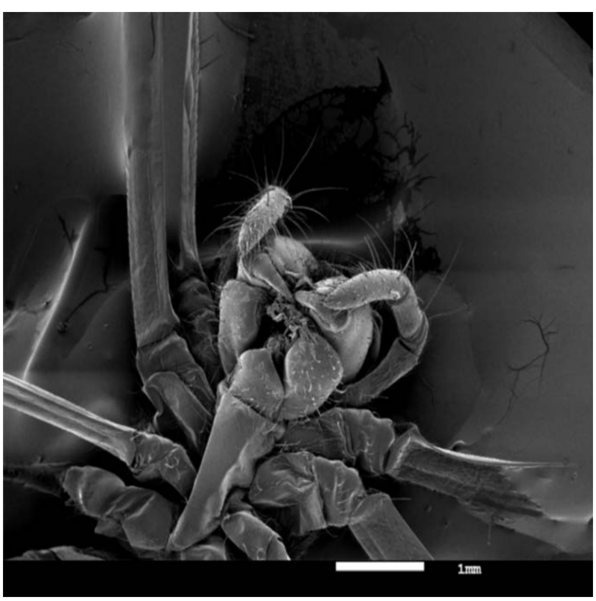
II. Methodology

The ability to visually locate and essentially identify individual her GSR particles, which are only a few micrometers in size, is otherwise impossible. In another example of wound assessment, SEM was used to visualize tool his marks on bone and compare them.

Bone and associated tissues are excellent media for recording and documenting tool marks such as those made by knives, allowing conventional comparison of tool marks. We can also determine the direction of the cut and whether it was cut with fresh or dry bone. This is an important distinction in forensic examination. A scanning electron microscope (SEM, Tescan VEGA II SBH) was used to observe the morphology of the titanate nanowires.

III. Results & Discussion

In this study, an X-ray diffractometer (XRD, Rigaku MiniFlex II) was used to analyze the crystal structure of titanate nanowires. For elemental composition analysis, the technique of energy dispersive X-ray diffraction (EDX) (Bruker AXS Microanalysis GmbH Berlin, Germany, EDX system) was used. All results for the above characterization parameters (SEM, XRD, and EDX) have been previously described in detail.



Biomaterial approaches to restoring tissues and organs by exploitation different bio fabrication methods and materials, specializing in recent advances within the field of tissue engineering and regenerative medicine. Papers cowl the planning of biomaterials and devices to be applied in vivo and in vitro, and a spread of topics regarding somatic cell biology, biomaterials and technological approaches. Specific topics embrace the generation of recent useful internalorgan substitutes, enhancements in the bone repair process, neural tissue formation, a pioneering model of viscus fibrosis, and therefore the creation of a completely unique vein valve prosthesis. This multi-disciplinary approach highlights however the various characteristics of biomaterials and devices are to blame for the promotion of cell integration, and ultimately new tissue formation. This issue may be a must-read for biomaterial scientists, tissue engineers, clinicians, in addition as somatic cell biologists concerned in basic analysis and its applications.

Lithium-ion batteries (LIBs) are important energy-storage devices in fashionable society. However, the performance and value are still not satisfactory in terms of energy density, power density, cycle life, safety, etcetera To more improve the performance of batteries, ancient “trial-and-error” processes need a massive variety of tedious experiments.

Procedure chemistry and computing (AI) will con siderably accelerate the analysis and development of novel battery systems. Herein, a heterogeneous class of AI technology for predicting and discovering battery materials and estimating the state of the battery system is reviewed. sure-fire examples, the challenges of deploying AI in real-world scenarios, and an integrated framework are analyzed and outlined.

IV. Conclusion

The progressive analysis concerning the applications of millilitre within the property prediction and battery discovery, as well as solution and conductor materials, are more summarized. Meanwhile, the prediction of battery states is additionally provided.

Finally, varied existing challenges and also the framework to tackle the challenges on the further development of machine learning for reversible LIBs are proposed. http://orcid.org/0000-0002-5091-3663.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

A Flaw in Hubble Law

By Salah A. Mabkhout
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Abstract- There is an approximately linear relationship between redshift and distance at small scales for all the FLRW models, and departures from linearity at larger scales can be used to measure *spatial curvature*. Hubble's law describes a uniformly expanding flat universe. Hubble's law says: the furthest object recedes faster than the nearest one. Hubble's law doesn`t explain why distant objects were receding fastest. We show this is not true. Unless there is a convincing reason confirms that the furthest object speeds faster than the nearest one, the two objects recede from the observer by the same velocity. The analogy of the surface of the balloon: that the furthest point recedes fastest is misleading, since the balloon is inflated from a preferred point, violates the isotropic principle. The problem relies on the similarity of the cosmological redshift to the Doppler redshift that both of them cause recession speed. This happened because the only cause of redshift that Hubble was aware was the common Doppler redshift. If cosmological redshift has nothing to do with the Doppler Effect, how do we know that galaxies that are very far away are also receding faster from us?

Keywords: *hubble law, cosmological redshift, doppler redshift.*

GJSFR-A Classification: *DDC Code: 720 LCC Code: NA2790*

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A Flaw in Hubble Law

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Keywords: hubble law, cosmological redshift, doppler redshift.

I. Introduction

The cosmological redshift is a consequence of the changing size of the universe; it is not related to velocity at all. The gravitational redshift in curved expanding spacetime is a generalization of the Doppler shift in flat spacetime to curved expanding spacetime, is the reddening of light from distant galaxies as the universe expands. In the widely accepted cosmological model based on General relativity, redshift is mainly a result of the expansion of space: this means that the farther away a galaxy is from us, the more the space has expanded in the time since the light left that galaxy, so the more the light has been stretched, the more redshifted the light is, and so the faster it appears to be moving away from us. Hubble's law follows in part from the Copernican principle. Light waves become stretched in route between the time they were emitted long ago, and the time they are detected by us today. It is tempting to refer to cosmological redshifts as Doppler shifts. By referring to cosmological redshifts as Doppler shifts, we are insisting that our Newtonian intuition about motion still applies without significant change to the cosmological arena. A result of this thinking is that quasars now being detected at redshifts of z = 4.0 would have to be interpreted as traveling a speeds of more than $V = z \times c$ or 4 times the speed of light. This is, of course, quite absurd, because we all know that no physical object may travel faster than the speed of light. To avoid such apparently nonsensical speeds, many popularizers use the special relativistic Doppler formula to show that quasars are really not moving faster than light. The argument being that for large velocities, special relativity replaces Newtonian physics as the correct framework for interpreting the world. By using a special relativistic velocity addition formula the quasar we just discussed has a velocity of 92 percent the speed of light. Although we now have a feeling that Reason has returned to our description of the universe, in fact, we have only replaced one incomplete explanation for another. The calculation of the quasar's speed now presupposes that special relativity (a theory of flat spacetime) is applicable even at cosmological scales where general relativity predicts that spacetime curvature becomes important. The special relativistic Doppler formula is introduced to show how quasars are moving slower than the speed of light! It is also common for popularizers of cosmology to describe how 'space itself stretches' yet continue to describe the expansion of the universe as motion governed by the restrictions of special relativity. By adopting general relativity as the proper guide, such contradictions are eliminated [1]. General relativity must replace special relativity in cosmology because it denies a special role to observers moving at constant velocity, extending special relativity into the arena of accelerated observers. It also denies a special significance to special relativity's flat spacetime by relegating it to only a microscopic domain within a larger geometric possibility. Just as Newtonian physics gave way to special relativity for describing high speed motion, so too does special relativity give way to general relativity. This means that the special relativistic Doppler formula should not, in fact cannot, be used to quantify the velocity of distant quasars. We have no choice in this matter if we want to maintain the logical integrity of both theories. The instantaneous physical distance is not itself observable. Cosmological 'motion' cannot be directly observed. It can only be inferred from observations of the cosmological redshift, which general relativity then tells us that the universe is expanding.

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II. Hubble`s Law

One of the most remarkable discoveries in twentieth century astronomy was Hubble's (1929) observation that the redshifts of spectral lines in galaxies increase linearly with their distance. Hubble took this to show that the universe is *expanding uniformly,* and this effect can be given a straightforward qualitative explanation in the FLRW models. The FLRW models predict a change in frequency of light from distant objects that depends directly on scale factor R(t). There is an approximately linear relationship between *redshift* and distance at small scales for all the FLRW models, and *departures* from linearity at larger scales can be used to *measure spatial curvature*. Hubble's law (V_{rec} = HD: recession velocity = Hubble's constant × distance) describes the situation: farthest objects receding fastest. It didn't explain why? Hubble himself was not entirely happy with his distance–velocity formula, which decisively contributed to the inflationary model of the universe. In the paper, jointly with Tolman, he wrote ―*The possibility that the redshift may be due to some other cause connected with the long time or distance involved in the passage of light from nebulae to observer, should not be prematurely neglected*.‖[2]

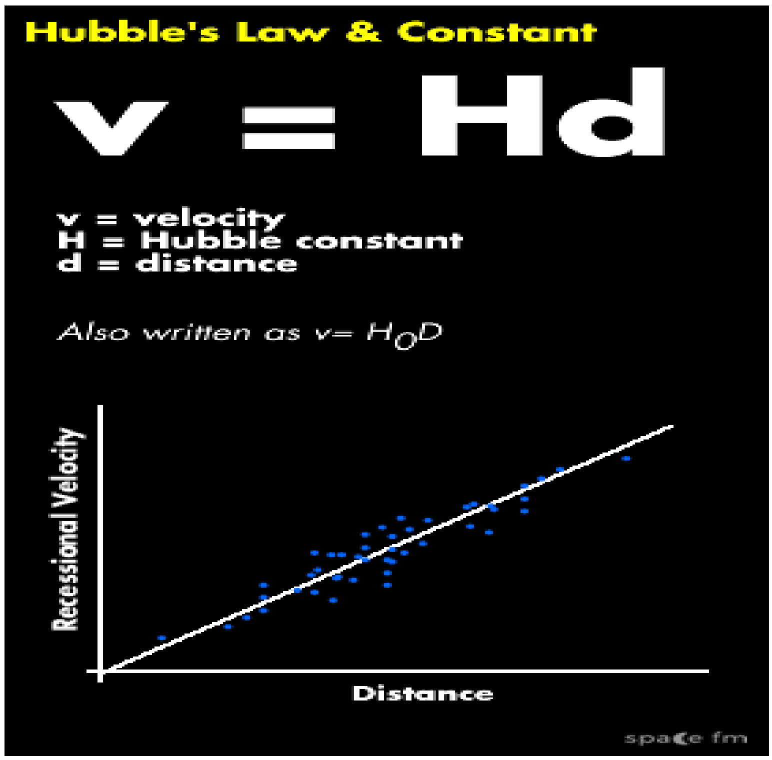


Fig. (1): Hubble law [3]

"The Hubble velocity distance rule is an interesting example how two independently correct facts, i.e. the common Doppler shift and Hubble's experimental distance vs redshift law when ―married‖ together resulted in an unfortunate conclusion. This happened because the only cause of redshift that Hubble was aware, was the common Doppler shift, and thus he obtained a distance–velocity plot" [4]." In a general setting and from a logical point of view, the existence of relative velocity is a necessary but not sufficient condition to record a wavelength shift. In Euclidean geometry e.g. wavelength shift uniquely implies existence of a relative velocity while in hyperbolic geometry it does not have a unique implication. Thus while the existence of relative velocity always results in a wavelength shift, the presence of a shift may or may not imply the existence of a relative velocity. Euclidean geometry cannot induce changes in wavelength of electromagnetic radiation. The case of $K = 0$. In Euclidean space geodesics do not deviate. This is the case of hyperbolic space. Geodesics deviate at an exponential rate" [4]. *If cosmological redshift has nothing to do with the Doppler effect*, how do we know that galaxies that are very far away are also receding from us? How to compare between two unrelated concepts, the Doppler redshift and the cosmological redshift? Andromeda galaxy is blueshifted because it's sufficiently nearby where the spacetime is approximately flat and special relativity dominates. Its blueshifted according to the Doppler Effect in flat spacetime. Andromeda one of about 100 blueshifted galaxies that we observe. Andromeda has a ―blueshift‖. It has a negative recessional velocity of roughly -300 km/s Andromeda's tangential or side-ways velocity with respect to the Milky Way is relatively much smaller than the approaching velocity. Locally the spacetime is flat

Global Journal of Science Frontier Research (A) Volume XXIII Issue II Version I Year 2023

no cosmological redshift, their blueshifts is just due to the Doppler Effect. What causes the peculiar velocity of the galaxy? Is it a free fall or something else? As you probably know, we interpret the redshifts of galaxies to mean that the universe is expanding. So if you could staple the galaxies to the 'fabric' of space, all of them would appear to be moving away from us -the farther away they are, the faster! Why? This is cheating! According to the isotropy principle our position is not preferred. Conversely the farther observer would see our nearby objects recede faster with respect to him than his nearby objects! A contradiction.

III. Cosmological Redshift Paradox

If an isolated object is x distant and y redshifted from an observer, how could he decide whether it is a Doppler redshift or a cosmological redshift? Where is the border in the space strictly separating the expansion of the space from the expansion within the space. How could the photon aware weather it travels either through a cosmological path or an intergalactic path in order to experience either a cosmological redshift or a Doppler redshift, respectively?

An object O is in the middle between two objects A and B. To visualize the picture, think of the three objects as they were fixed in the fabric of the spacetime. Due to the expansion of the spacetime each object moves away from each other; as if the middle one is fixed while the two others move away from it. An observer on A would receive a cosmological redshift from B that is greater than the cosmological redshift that he received from O. Accordingly, to an observer at A; B would recede faster than O. After a time t, the distance separating O and B would be greater than that separating A and O. Since the spacetime is *isotropic*, there is no preferred position. Did an observer on B agree with this picture? An observer on B, conversely, would find after time t that the distance separating O and A would be greater than that separating O and B. Whom should we believe? It would be a paradox if we believed both of them. The cosmological redshift and its consequence recession velocity are no longer a distance indicator. We must seek for another cause for the cosmological redshift? We interpret the cosmological redshift as a curvature`s manifest.

Hubble's law doesn`t explain why distant objects were receding fastest

Again consider a point O is equidistance d in-between two points A and B. Fig.(2). If the expansion of the spacetime is doubled, i.e. O would be equidistance 2d from both points A and B. It was mistakenly [5] calculated that the rescission velocity of B from A is double than that of O from A

$$V_{AB} = \frac{4d - 2d}{\Delta t} = \frac{2d}{\Delta t}$$

$$V_{OA} = \frac{2d - d}{\Delta t} = \frac{d}{\Delta t}$$

Hence, we conclude: B (the furthest from A) recedes faster from A than O does.

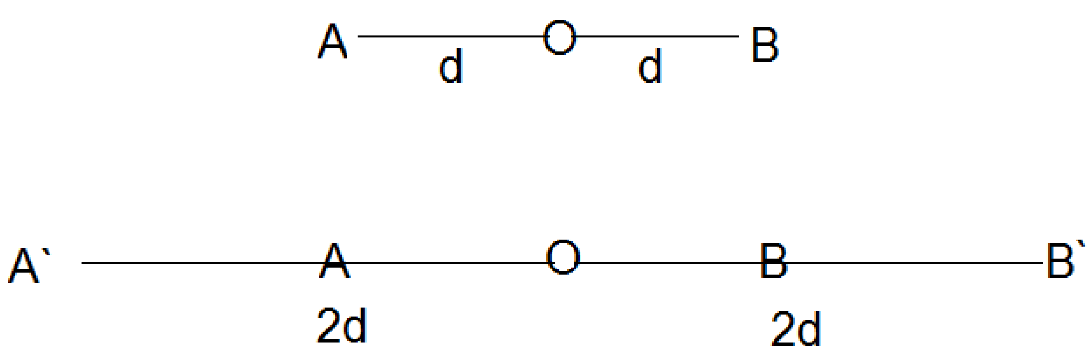


Fig. (2)

The misconception is that, B was actually shifted 3d from the original position of A, i.e.

$$V_{AB} = \frac{3d - 2d}{\Delta t} = \frac{d}{\Delta t}$$

$$V_{OA} = \frac{2d - d}{\Delta t} = \frac{d}{\Delta t}$$

To overcome this confusion, we visualize the previous picture from a different point of view, Fig. (3). Assume a right triangle OAB. The vertex O at the right angle d distance from the vertex A and 2d distance from the other vertex B. After time Δt, if the vertex A recedes an additional distance d from O such that $OA\ d = 2$ then B also will recede an additional distance d from O such that $OB\ d = 3$, then

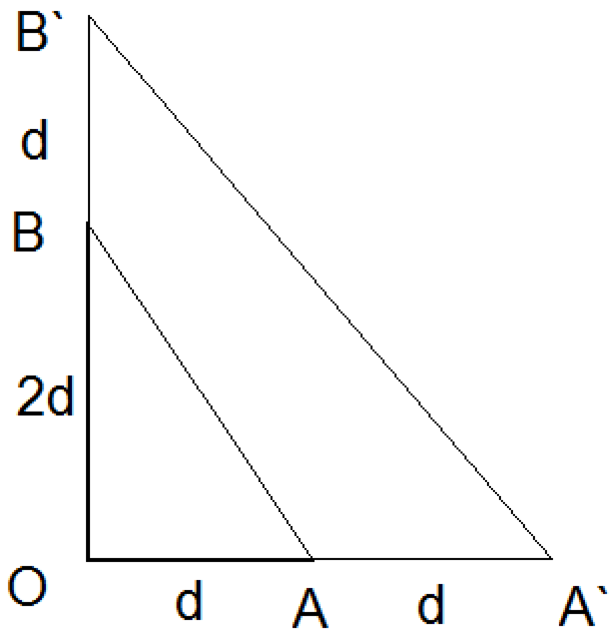
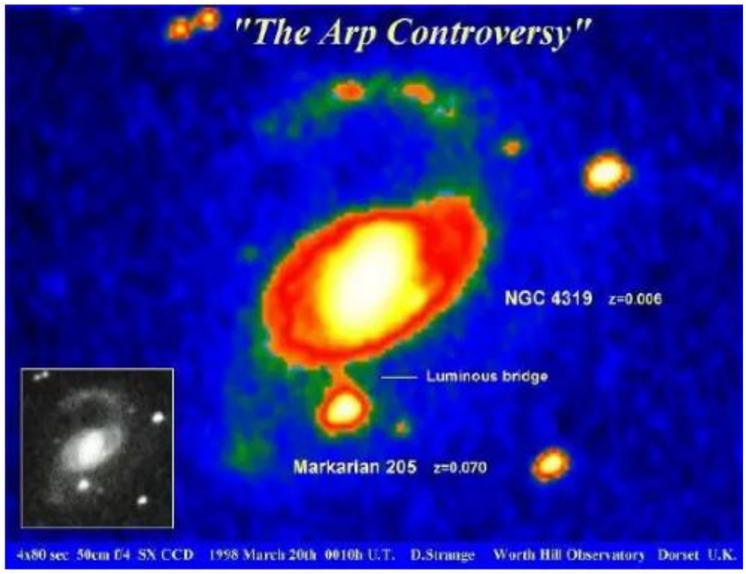


Fig. (3)

Unless there is a convincing reason led B to speed faster than A, the two points recede from O by the same velocity. If we assume priory the separating distances were doubled after time $\Delta t(OB\ d\ OA\ d = = 4$, 2)then B recedes from O faster than A. So, we conclude what we already assumed. Hubble's law doesn`t explain why distant objects were receding fastest.

IV. Quasar`s Redshift in Conflict with Hubble Law

Quasars are believed to be objects ejected from the centers of the Galaxies or Black holes. According to Hubble`s law, if the object is bright then its low redshifted and nearby while the distant object is faint and high redshifted. The Quasars are very bright, so why they shouldn`t be nearby? Why we just accept one part from Hubble`s law, that is: the high redshift of the Quasar indicates that its distant and ignored the other part, that is: the brightness of the Quasars indicate they are nearby? Finally, why our Galaxy and many other nearby Galaxies didn`t eject Quasars from their centers? Why this job is exclusive for distant Galaxies? Because our Galaxy and many others nearby Galaxies are inactive, said astronomers. Why they are the inactive among the active distant Galaxies? It is clear such a paradigm is not satisfactory and insufficient, it depends on many unjustified reasons, many contradictions and inconsistent. The paradigm must be reconsidered and readjusted. The bright the Quasar, the high it`s redshift and the distant it is. The bright the Galaxy the low redshift, the nearby it is. Brightest Galaxies associated with brightest Quasars, but faint Galaxies not. So, if the Quasars agree in their brightness they disagree with their redshifts. Yes, the scenario concerning the Quasars no more than speculations and guesses to fabricate suitable explanations to fit current observations. The problem relies on the similarity of the cosmological redshift to the Doppler redshift that both of them cause recession speed. The first by the expansion of the spacetime and the other by receding within the spacetime. If the high redshift of the Quasar is due to the cosmological redshift of the expanding spacetime, why it shouldn't agree and coincide with the redshift of the hosting Galaxy. The anomalous pair NGC 4319 and M 205: [16]



The anomalous pair NGC 4319 and M 205

The cosmological redshift must be interpreted in a different way, as I do, as manifests the curvature of the hyperbolic spacetime. Astronomers have found many galaxy pairs and galaxy groups in which the members are evidently close to each other —even interacting— yet have redshifts that are radically at odds! Their redshifts don't make sense: If two galaxies are roughly in the same place then their measured redshifts should agree with each other, since redshift is supposed to be a measure of their distance (although the redshift may include a relatively minor Doppler component due to local motion). The observational fact that they don't is considered anomalous. The mystery is in the cause, and also why some of the anomalies are so extreme. "*Locally the spacetime is flat, where special relativity together with its Doppler redshift dominates to measure peculiar velocities, there is no cosmological redshift in this case. For distant objects the spacetime is hyperbolic where the cosmological redshift manifests the curvature*" [6]. For example, observations tell us that space within galaxies, which are rather diffuse objects, do not expand. Thus, where is the —border linell in space which divides expanding space from non expanding space?

V. Quasars Redshifts Don`t Exhibit Time Dilation

The phenomenon of time dilation is a strange yet experimentally confirmed effect of relativity theory. One of its implications is that events occurring in distant parts of the universe should appear to occur more slowly than events located closer to us. Relativity has shown that anything causing a change in lengths (length contraction) must also affect time as well (time dilation).

Wavelength times frequency always equals the speed of the wave. For light $\lambda\nu = c$. The inverse of the frequency is time. Hence the expanding universe produces a cosmological time dilation; as well as redshift.

$$\frac{\nu_{em}}{\nu_{rec}} = \frac{\lambda_{rec}}{\lambda_{em}} = \frac{R_{now}}{R_{then}} = 1 + z$$

For example, suppose that a clock attached to a Quasar with a very large redshift measures the frequency of a particular ultraviolet light beam, emitted within the Quasar, as 10^{15} cycles per second. We receive it on Earth shifted into the infrared, with a frequency 10^{14} cycles per second. Thus it takes 10 of our seconds for us to see the Quasar clock tick off one Quasar second. For example, when observing supernovae, scientists have found that distant explosions seem to fade more slowly than the quickly-fading nearby supernovae. However, a new study has found that this doesn't seem to be the case - quasars, it seems, give off light pulses at the same rate no matter their distance from the Earth, without a hint of time dilation. Astronomer Mike Hawkins from the Royal Observatory in Edinburgh came to this conclusion after looking at nearly 900 quasars over periods of up to 28 years. When comparing the light patterns of quasars located about 6 billion light years from us and those located 10 billion light years away, he was surprised to find that the light signatures of the two samples were exactly the same. If these quasars were like the previously observed supernovae, an observer would expect to see longer, —stretchedll timescales for the distant, —stretchedll high redshift quasars. But even though the distant quasars were more strongly redshifted than the closer quasars, there was no difference in the time it took the light to reach Earth. [7].

Quasars have redshifts variation not correlated with time dilation. The light signature of quasars located 6 billion light years from us and those 10 billion light

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years away were exactly the same, without a hint of time dilation. This quasar conundrum doesn`t seem to have an obvious explanation. Thus the high redshifts of quasars may not necessarily represent their distances.

Further, in some observations, the redshifts have been found to exhibit some periodicity in their distributions as represented by the Karlsson formula [8].

The periodicity further makes it difficult for the redshift to represent distance. M Hawkins is very clear, his finding is that: the redshift of the Quasars do not exhibit time dilation. Moreover, he gave many suggestions [9].

1. It means the quasars may be nearby, not as distant as their redshifts and the Hubble law would indicate.
2. The origin of all matter was not at the big bang but over time in a grand ongoing creation scenario.
3. The Universe is not expanding.
4. Several explanations are discussed, including the possibility that time dilation effects are exactly offset by an increase in timescale of variation associated with black hole growth, or that the variations are caused by microlensing in which case time dilation would not be expected. [9].

In April 2010, Marcus Chown wrote in an article entitled [10] ―Time waits for no quasar―even though it should‖ for New Scientist online. The edifice of the big bang hangs on the interpretation that the quasar redshifts are cosmological. If they are not: it brings into question the origin of quasars, and, it means the quasars may be nearby, not as distant as their redshifts and the Hubble law would indicate. This latter idea is linked to the work of Halton Arp [11] and others that showed strong correlation between parent galaxies that have ejected quasars from their active cores. The origin of all matter was not at the big bang but over time in a grand ongoing creation scenario. Arp [11] believed quasars were ejected from the active hearts of parent galaxies and their redshifts were largely intrinsic, not distance related. Because most of the high redshift objects in the Universe are quasars, if their redshifts are due to cosmological expansion then they are good evidence for an expanding universe. If the quasar redshifts are not reliable as a distance indicator, as Arp's hypothesis of ejection of quasars from the active cores of relatively nearby galaxies suggests, then the conclusion that the universe is expanding can be avoided. Arp, in fact, believed in a static universe [11]. The Hubble law, determined from the redshifts of galaxies, for the past 80 years, has been used as strong evidence for an expanding universe. This claim is reviewed in light of the claimed lack of necessary evidence for time dilation in quasar and gamma-ray burst luminosity variations and other lines of evidence. It is concluded that the observations could be used to describe either a static universe (where the Hubble law results from some as-yet-unknown mechanism) or an expanding universe described by the standard cold dark matter model. In the latter case, size evolution of galaxies is necessary for agreement with observations. Yet the simple non-expanding Euclidean universe fits most data with the least number of assumptions [12].

VI. Tension between the Values of Hubble Constant

The ΛCold Dark Matter model (ΛCDM) represents the current standard model in cosmology. Within this, there is a tension between the value of the Hubble constant, H_0, inferred from the local distance ladder (H_0=73(Km/sec)/Mpc) and the angular scale of fluctuations in the Cosmic Microwave Background CMB (H_0=67(Km/sec)/Mpc).

Universe is expanding. One camp of scientists, the same camp that won the Nobel Prize for discovering dark energy, measured the expansion rate to be 73 km/s/Mpc, with an uncertainty of only 2.4%. But a second method, based on the leftover relics from the Big Bang, reveals an answer that's incompatibly lower at 67 km/s/Mpc, with an uncertainty of only 1%. It's possible that one of the teams has an unidentified error that's causing this discrepancy, but independent checks have failed to show any cracks in either analysis. Instead, new physics might be the culprit. If everyone measured the same rate for the expanding Universe, there would be nothing to challenge this picture, known as standard ΛCDM. But everyone doesn't measure the same rate. Currently, the fact that distance ladder measurements say the Universe expands 9% faster than the leftover relic method is one of the greatest puzzles in modern cosmology. The universe is currently expanding too fast — faster than theorists predict when they extrapolate from the early universe to the present day. ―If the late and early universe don't agree, we have to be open to the possibility of new physics,‖. A mathematical discrepancy in the expansion rate of the Universe is now "pretty serious", and could point the way to a major discovery in physics, says a Nobel laureate; Prof Riess [13].

VII. Hubble constant for the Hyperbolic Universe

Given the values of the observed average density of the universe and the cosmic horizon, we can calculate the value of the Hubble constant in the hyperbolic universe (k = -1),

$$\rho_{observed} = 3\times10^{-31}\, g/cm^3$$

$$\because 1g = 7.425\times10^{-29}\, cm$$

$$\therefore \rho_{observed} = \left(3\times7.425\times10^{-60}\, cm^{-2}\right)$$

$$\dot{R}^2 + k = \frac{8\pi}{3}\rho R^2$$

$$\rho_{observed} = 3\times7.425\times10^{-60}\, cm^{-2}$$

$$H^2 = \frac{\dot{R}^2}{R^2} = \left(\frac{\dot{R}}{R}\right)^2 = \frac{8\pi}{3}\rho_{observed} - \frac{k}{R^2}$$

$$\because k = -1$$

$$H^2 = \frac{8\pi\times3\times7.425\times10^{-60}}{3}cm^{-2} + \frac{1}{\left(1.3\times10^{28}\right)^2 cm^2}$$

$$= \left[\frac{8\pi\times3\times7.425}{3} + \frac{10^4}{1.69}\right]\times10^{-60}\, cm^{-2}$$

$$H = \sqrt{\left[\frac{8\pi\times3\times7.425}{3} + \frac{10^4}{1.69}\right]\times10^{-60}\, cm^{-2}}$$

$$H = \sqrt{\left[\frac{8\pi\times3\times7.425}{3} + \frac{10^4}{1.69}\right]}\times10^{-30}\, cm^{-1}$$

$$H = \sqrt{186.6105 + 5917.1598}\times10^{-30}\, cm^{-1}$$

$$H = \sqrt{6103.77}\times10^{-30}\, cm^{-1}$$

$$H = 78.1266\times10^{-30}\, cm^{-1}$$

$$Mpc = 3.09\times10^{24}\, cm$$

$$1\sec = 2.997\times10^{10}\, cm$$

$$1km = 10^5 cm$$

$$[(km/\sec)/Mpc] = [(10^5 cm/2.997\times 10^{10} cm)/3.09\times 10^{24} cm]$$

$$[(km/\sec)/Mpc] = 1.08\times 10^{-30} cm^{-1}$$

$$cm^{-1} = \frac{[(km/\sec)/Mpc]}{1.08\times 10^{-30}}$$

$$H = 78.1266\times 10^{-30} cm^{-1}$$

$$H = \frac{78.1266}{1.08}(km/\sec)/Mpc$$

$$H = 72.3(km/\sec)/Mpc$$

We calculate Hubble constant from our hyperbolic scale factor [14], [15],

$$R_{now} = \sqrt{3/8\pi\rho_{now}}\sinh t_{now}\sqrt{8\pi\rho_{now}/3}$$

$$R_{now} = \sqrt{3/(8\pi\times 7.425\times 10^{-60})}$$

$$\times\sinh\left[1.32587\times 10^{28}\times\sqrt{8\pi\times 7.425\times 10^{-60}/3}\right]$$

$$R_{now} = 1.6\times 10^{29}\times\sinh 0.08287 cm = 1.3\times 10^{28} cm$$

$$\dot{R} = \cosh t_{now}\sqrt{8\pi\rho_{now}/3}$$

$$\because \sinh 0.08287 = \frac{1.3}{16}$$

$$\therefore \cosh 0.08287 = \sqrt{1+\left(\frac{1.3}{16}\right)^2} = 1.0103$$

$$H = \frac{\dot{R}}{R} = \frac{\cosh t_{now}\sqrt{8\pi\rho_{now}/3}}{\sqrt{3/8\pi\rho_{now}}\sinh t\sqrt{8\pi\rho_{now}/3}}$$

$$H = \frac{1.0103}{1.3 \times 10^{28} cm} = 77.72 \times 10^{-30} cm^{-1}$$

$$H = 72\left(\left(km/s\right)/Mpc\right).$$

The theoretical calculated value of Hubble constant in the hyperbolic universe (without invoking Dark Matter and Dark Energy) is very consistent with the observed value inferred from the standard candles. Our Hyperbolic Universe paradigm provides a new physics resolves the tension in the values of H_0 inferred from the local distance ladder and the angular scale of fluctuations in the Cosmic Microwave Background CMB.

Hubble constant For flat universe,

$$\because 1g = 7.425 \times 10^{-29} cm$$

$$\rho_{critical} = 10^{-29} g/cm^3 = 7.425 \times 10^{-58} cm^{-2}$$

The Hubble constant for flat universe with a critical energy-density, where k=0

$$H = \sqrt{\frac{8\pi}{3}\rho_{critical} - \frac{k}{R^2}}$$

$$\because k = 0$$

$$H = \sqrt{\left[\frac{8\pi \times \rho_c}{3}\right]}$$

$$\rho_c = 7.425 \times 10^{-58} cm^{-2}$$

$$H = \sqrt{[62.2035 \times 100]} \times 10^{-30} cm^{-1}$$

$$H = 78.8692 \times 10^{-30} cm^{-1}$$

$$H = \frac{78.8692}{1.08}\left(\left(km/s\right)/Mpc\right)$$

$$H = 73\left(km/s\right)/Mpc$$

Note that if we assume a flat universe and we substitute the observable density of the universe to obtain Hubble constant,

$$H = \sqrt{\frac{8\pi}{3}\rho_{observed} - \frac{k}{R^2}}$$

$$\because k = 0$$

$$H=\sqrt{\left[\frac{8\pi\times\rho_{observed}}{3}\right]}$$

$$\rho_{observed}=3\times7.425\times10^{-60}cm^{-2}$$

$$H=\sqrt{\left[\frac{8\pi\times3\times7.425}{3}\right]}\times10^{-30}cm^{-1}$$

$$H=\sqrt{186.61}\times10^{-30}cm^{-1}$$

$$H=13.66\times10^{-30}cm^{-1}$$

$$H=\frac{13.66}{1.08}\left((km/s)/Mpc\right)$$

$$H=12.65\left((km/s)/Mpc\right)$$

VI. Conclusion

- Hubble's law says: the furthest object recedes faster than the nearest one. Hubble's law doesn`t explain why distant objects were receding fastest. We show this is not true.
- Quasar`s redshift in conflict with Hubble law.
- Quasars Redshifts Don`t Exhibit Time Dilation.
- Tension between the values of Hubble constant.
- We interpret the cosmological redshift as a curvature`s manifest. –
- We calculate Hubble constant theoretically due to the hyperbolic universe: H_0=72.3 (km/s)/Mpc agrees current observation.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Spark of First Life and Consciousness

By Chandra Prakash Trivedi

Abstract- The electrostatic force is the force that governs the motion of the elementary particles, which causes them to aggregate or collide in various ways with oxidation and reduction with the transfer of electrons in the primordial soup. The vibratory movement of the charged ions with equal and opposite wavelengths developed a dynamo streaming in extreme anaerobic.

It has been observed in the ultra-resolution image that one purine and one pyrimidine base differing only in Nitrogen are complimentary to each other shed with cosmology. The elementary particles adhered to space, and the sound of vibration touched, press the mark, and rebound. The colliding protons decayed into hadron jets, and the electrons converted them into electric vibrations to join the purine and pyrimidine base in series with mass.

Keywords: spark of life, phonon, slime soup.

GJSFR-A Classification: DDC Code: 843.914 LCC Code: PQ2668.O77

SPARKOFFIRSTLIFEANDCONSCIOUSNESS

Strictly as per the compliance and regulations of:

Spark of First Life and Consciousness

Chandra Prakash Trivedi

Abstract- The electrostatic force is the force that governs the motion of the elementary particles, which causes them to aggregate or collide in various ways with oxidation and reduction with the transfer of electrons in the primordial soup. The vibratory movement of the charged ions with equal and opposite wavelengths developed a dynamo streaming in extreme anaerobic.

It has been observed in the ultra-resolution image that one purine and one pyrimidine base differing only in Nitrogen are complimentary to each other shed with cosmology. The elementary particles adhered to space, and the sound of vibration touched, press the mark, and rebound. The colliding protons decayed into hadron jets, and the electrons converted them into electric vibrations to join the purine and pyrimidine base in series with mass.

The electrostatic interaction between the charged ions of the water with dehydration separated the hydrogen bond. It has formed a covalent Hydrogen bond between the purine and pyrimidine complementary base. The complementary wavelength of the hydrogen bond activated the nucleotide pair with the transfer of electrons. The hydrogen triple bond converts into the double bond and reunited on the opposite side with a change in the electron with oxidation and reduction in the chain with the first genetic code and amino acid in series. The synthesized chromosomes are divided into four with the first prokaryotic cell. Life appears with the streaming of the protoplasm and disappears with the aging of the cell. The complementary wavelength of the hydrogen triple bond of the nucleotide pair led to the development of from generation to generation with new life.

Keywords: *spark of life, phonon, slime soup*.

I. Introduction

Origin of life consciousness is a great puzzle, life appears with the streaming of the protoplasm and disappears with the aging of the cell body. I have traced the roots of life consciousness in pre-cosmic conditions. The phonon wave appeared first and activated the dark matter with a blast and light. The phonon and photon run parallel with equal and opposite wavelengths. The purine and pyrimidine bases differ only in Nitrogen shed-like bullets with incandescent gaseous clouds with phonon photon interaction with the vibrations. The electrostatic force governs the motion of the elementary particles, which caused them to aggregate or collide in various ways with oxidation and reduction with the transfer of electrons in the primordial soup. It has activated the purine and the pyrimidine complementary base pair with resonance.

The electrostatic interaction between the charged ions of the water with dehydration separated the hydrogen bond. It has formed a covalent Hydrogen bond between the purine and pyrimidine complementary base. The complementary wavelength of the hydrogen bond activated the nucleotide pair with the transfer of electrons. The hydrogen triple bond converts into the double bond and reunited on the opposite side with a change in the electron with oxidation and reduction in the chain with the first genetic code and amino acid in series. The synthesized chromosomes are divided into four with the first prokaryotic cell. Life appears with the streaming of the protoplasm and disappears with the aging of the cell. The complementary wavelength of the hydrogen triple bond of the nucleotide pair led to the development from generation to generation with new life.

II. Early Work

The Russian Chemist A.I. Oparin 1922 and English Geneticist J.B.S. Haldane 1928 first conceived of the theory of the pre-biotic origin of life. DNA Watson and Crick 1953, Darwin Origin of Species 1859, Life evolved from the single DNA with Genetic recombination and cell division. How did the first Life begin? NASA researchers noticed polycyclic aromatic hydrocarbons (PAHs) in meteorites. Extra hydrogen or oxygen called Quinone has the potential for the origin of life.

Higgs field 1914, phonon scattered the photon in a crystal Lie et al 2014, Einstein 1923 there must be two equal and opposite forces. The photon is the smallest unit of light, and the immortal phonon is the smallest unit of the sound wave vibration connected at the molecular level with equal and opposite wavelengths.

The DNA with photon-phonon interaction is universally present. Hence its complimentary resonant wave blackouts radio communications on the earth and the protons damage human beings in space if not protected properly. Because the entry of radiation rays with protons checked by the magnetosphere and ozone layer and complimentary resonance finds its counterpart protons astronaut human in space.

III. Life on the Earth

The incandescent gaseous cloud cooled down with time and the movement of the molten mass generated the geomagnetic field and magnetosphere around the earth has given the place for the ionization of the solar flares trapped by the magnetosphere and interacts with the sun's magnetic field. The ions flow down and filled the earth with water.

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IV. Ozone Layer

Stratospheric ozone is formed naturally through the interaction of solar ultraviolet (UV) radiation with molecular oxygen (O2). Ozone absorbs the toxic UV rays with the entry of visible light, it has given the way for the origin of life on the earth.

Theory

I have traced its root in pre-cosmic cosmology and the sun.

The earth is a part of our solar system, which is one unit of the cosmos. The human body is a microcosm inside a macrocosm. All can be searched just like a drop of water in the sea can reveal the character of the ocean I have studied the sun with the naked eyes with my yogic practice otherwise it is impossible to face the sun even for a second with confirmation from Egypt Rosetta granite stone, pyramids of Egypt, Gold plate Grand Canyon North. America, NASA pictures & Veda,

I have observed the nuclear reactions on the sun's surface with blasts and light. The photon and phonon run in a straight way in concentric circles. It has been confirmed from the Sun disc gold plate Grand Canyon and Veda.

The digitally stacked sequence reveals that the photon and phonon running in concentric circles from the sun Grand Canyon Star Trails NASA - March 3, 2013. Scientists are searching the Dark matter, which is not matter. The dark atmosphere is hidden in the interior of the sun, black caters, and sunspots, which explode with blasts and light.

The shock waves are antimagnetic, white, and travel with supersonic speed, and dark matter is an inactive condensed zone of magnetism without movement, just like a waste. The shock waves are 'anti-matter of dark matter, immortal with opposite character. It appears first in the pre-cosmic darkness like the shock waves appear before the earthquake, and activated the dark matter with resonance with blast and light. The photon and photon are complementary to each other.

The activation of dark matter is the activation of inherent magnetism in the cosmos, with the formation of charged elementary particles. The electrostatic force is the force that governs the motion of the elementary particles, which caused them to aggregate or collide in various ways with oxidation and reduction with the transfer of electrons.

The photon and phonon have a broad complementary spectrum from gamma rays to radio waves with equal and opposite wavelengths. The immortal phonon stimulates the event with electron configuration and half-spin change in the opposite wavelength and the photon undergoes the synthesis and degradation with time Einstein's Equation $E=Mc^2$.

The flow of the photon and photon has been halted with the Higgs field underlying space imparted mass to the elementary particles.

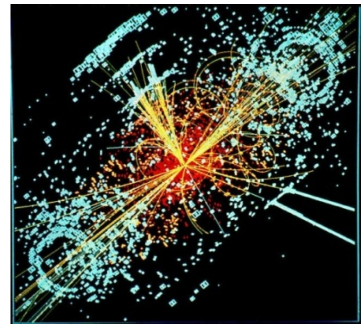


Fig. 1: Higgs field and mass to the elementary particles

All elementary particles are vibrating with the resonance of vibration and their respective charge. They are complementary to each other from gamma rays to radio waves. They find their resonance with resonance. The resonant vibrations of electromagnetic rays, touch, press-mark, and rebound. The colliding protons, decaying into hadron jets and electrons, converted them into electric vibrations to join them in series with phonic compression electromagnetic force. It has maintained its continuity in the molecules and the matter with Higgs field 2013 with asteroids and planets.

V. Discussion

All elementary particles are vibrating with the resonance of vibration and their respective charge. They are complementary to each other from gamma rays to radio waves. They find their resonance with resonance. The phonon touch press mark and rebound with electron configuration and the half spin change in the opposite wavelength, and the photon undergoes the synthesis and degradation with time Einstein's equation $E=Mc^2$

The first life arose in the primordial soup with the streaming movement of the charged ions in the colloidal solution. The respective complementary wavelength of the charged ions caused them to vibrate with streaming

The vibratory movement of the ions with streaming developed a dynamo in the center with actions and interactions in series with electron transfer and the photon undergoes synthesis and degradation with time.

The electron transfer is associated with the oxidation loss of an electron and reduction gain of the electron in anaerobic conditions. The electrostatic interaction between the charged ions developed a dynamo in the center with the electromagnetic field. The vibration waves activated the equal and opposite wavelengths of purine and pyrimidine base differing only in Nitrogen The elementary particles adhered to space, the sound of vibration, touched, press the mark, and rebound. The colliding protons, decaying into hadron jets and electrons, converted them into electric vibrations to join them in series with electron configuration and half spin change in the opposite wavelength.

The electrostatic interaction between the charged ions of the water with dehydration separated the hydrogen bond. It has formed a covalent Hydrogen bond between the purine and the pyrimidine base.

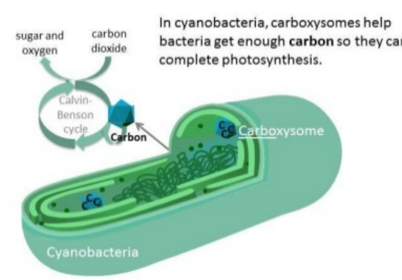
Fig. 2: Ultra-resolution image of DNA with Electron transfer

The phonon wave strike and rebound with a press mark with the electron configuration in the opposite direction of the hydrogen triple bond, it triggered off the chain of oxidation and reduction reaction, and the hydrogen triple bond is converted into a double bond and Nitrogen reunite it on the other side simultaneously.

The equal and opposite wavelengths of the hydrogen triple bonds led to the development of electron transfer. With the first genetic code and amino acid in series synthesized the chromosomes. The chromosomes are divided into four with the first prokaryotic cell. Life appears with the streaming of protoplasm with the food metabolism as a source of life and disappears with the aging and death of the cell body. The complementary wavelength of the hydrogen triple bond of the nucleotide pair led to the development from generation to generation with new life.

Fig. 3: The nucleotides divide in the air like an image in the mirror with electron transfer

The equal and the opposite wavelength of the hydrogen triple bond led to the development of electron transfer in series and the hydrogen triple converted into a double bond and reunited in the opposite direction simultaneously with Nitrogen in series as the identity of the individual cell with equal and opposite wavelength. Hence, even the time twins have different genetic identities and fates in life.



The prokaryotes evolved into the eukaryotic autotrophic cell with the entry of the red wavelength of light made apparent the three places of nucleotide pair with the photosynthesis and generation of immortal chemical energy. The immortal phonon wave follows the immortal DNA from generation to generation with new life and cell division.

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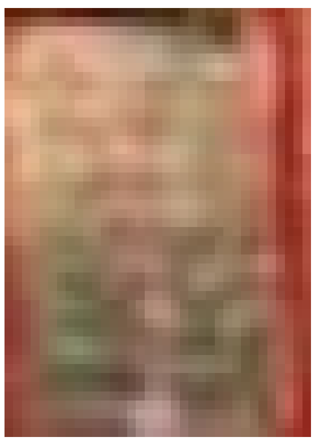
At the point of two different DNA the complementary phonon wave strike and rebound with the generation of triplet code in the air with electron configuration and half spin change in the opposite wavelength.



The complementary wavelength led to the development of vigorously

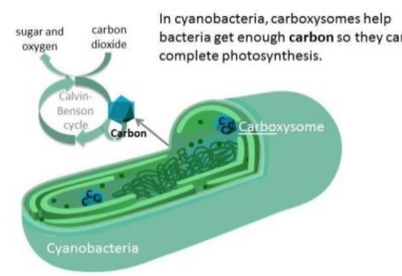
The triplet genetic code of DNA divides in chains with never breaking Nitrogen

The complementary phonon wavelength acts as an antenna and speaker to execute the functions of life, It led to the development of the synthesis of amino acids and proteins in the chain to synthesize the chromosome pair with the first prokaryote.

The Hydrogen triple bond Nitrogen triple bond with oxidation and reduction separate and unite simultaneously on another side, with oxidation the hydrogen bond break, and Nitrogen reunites it on another side, due to this the double helix chain never break.

VI. Result and Conclusion

The entry of the Red wavelength of light through the plasma membrane activated the place of the chlorophyll pigment on the DNA



The first prokaryotic cell with an incipient nucleus maintained its continuity with cell division, and immortal phonons follow it from generation to generation with new life.

The entry of the Red wavelength of light through the plasma membrane activated the place of the chlorophyll pigment on the DNA as a source of life with food metabolism.

It has given double horsepower to the developing cells and the prokaryotic autotrophic cell evolved into the eukaryotic cell and moved on the path of evolution with genetic recombination and cell division with the hereditary characters and the complementary phonon wave following it from generation to generation with new life as a hereditary life principle.

Life appears with the streaming of the protoplasmic vibrations with food metabolism and disappears with the aging of the cell body.

It is like this that all the rotating astronomical bodies rotate at their axis with the generation of the dynamo in the center with the magnetic field and the magnetosphere around them. In the same fashion, the streaming of the protoplasm with the nucleus in the center generates dynamo in the center with a magnetic field and magnetosphere but is hard to detect, which disappears with death, and aging of the cell body.

The purine and the pyrimidine base pair of DNA differing only in Nitrogen have shed from the Nebula with the cosmological event. It divides in the air just like the image in the mirror. The Purine and pyrimidine base pair of the DNA has an inbuilt mechanism for the transcription and translation with time, with three immortal and three stages of life. The three immortals are, 1- the Higgs field ensign of the existence, 2- the immortal chemical energy of photosynthesis, with food metabolism is the source of life. 3. The immortal DNA with resonant vibrations light of life for all.

Acknowledgment

I am thankful to the Director M. V. ShodhPeeth, Ujjain for their encouragement and to VC Vikram University, Ujjain.

Table 1

1.	Carol Stoker	Searching for Life Underground: Experiments with Drilling in Mars Analog Terrains
2.	David Summers	Detection of Biosignatures with highly sensitive radio-labeling techniques. The Stable Isotope Fractionation of Abiotic Reactions: A Benchmark in the Detection of Life

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Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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save our planet

Global Journal of Science Frontier Research

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ISSN 9755896