Hadron masses from a Kaluza-Klein like Model

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Abstract

The Standard Model of particle physics is re-interpreted in terms of Kaluza-Klein theory. In this paper, a model consisting of 10 dimensions is presented which are: one time, three usual macroscopic space and six compactified dimensions. Excitations - disturbances traveling with the speed of light on the 10D space-time - are introduced. An excitation on a compactified dimension induces a mass in 4D space-time; it is accompanied by an integer, the excitation number, and has a well-defined spin. The model's free parameters are computed using the measured masses of the leptons, including the upper bound of the mass difference between electron and positron, the mesons π^0, π^+, ρ^0, ϕ, ψ, Υ, the top-quark mass, and the magnetic moment of the electron. The most important parameters are the compactification radius ρ, the weak coupling α_w, the strong coupling α_s and the anti-neutrino to neutrino density ratio δ. The formulas for calculating hadron masses are given and applied to approximately one hundred composite particles, which are compiled within four separate tables. The comparison between the measurement and calculation shows the relative errors mostly below 0.05. δ appears to deviate marginally from one, which points towards slightly different densities when comparing anti-neutrinos to neutrinos.

Keywords: Kaluza-Klein theory, geodesic equation, hadron masses, Standard Model, anti-neutrino/neutrino density, neutrino mass

Introduction

The Standard Model of particle physics [1-7] is one of the most successful theories of physics. The strength of the model is its ability to explain the forces between particles as the exchange of bosons [8] wereby the photon in case of electromagnetism, the 8 gluons for the strong and the W^+, W^- and the Z for the weak interaction operate as mediators. One of the model's greatest successes is the calculation of the anomalous magnetic dipole moment of the electron through quantum mechanical corrections, as first introduced by Julian Schwinger in 1948 [9] with the first order correction on the predictions of the Dirac equation. Later, higher order corrections established the agreement between theoretical and experimental results of up to 12 significant digits [10].
There are however weaknesses such as the well-known failure to provide any information on dark matter and dark energy [11]; the inability to describe gravity; and the inability to calculate the hadron masses. Thus far, it appears that there is no room within the Standard Model for providing information with regards to dark matter and dark energy. For the missing

gravitational interaction, some extensions in the form of quantum gravity [12] with the spin-2 graviton that serves as an exchange boson, have been suggested. An additional shortcoming is the model's inability to calculate meson and baryon masses, the particles representing ordinary matter, and the unstable particles created in high-energy particle smashing experiments.

The Standard Model scenario involves the acting of various fields within the flat 4-dimensional space-time. General relativity [13], on the other hand, uses curved space-time to describe gravity on a larger scale - the main theory of cosmology [14]. But what if instead of looking for a graviton as the force creating boson of quantum gravity, the alternative could be a multi-dimensional space-time to describe the strong, the electromagnetic and the weak interactions? The first attempt dates back to the year 1921, when Theodor Kaluza [15, 16] presented a 5-dimensional model to include electromagnetism. The quantum aspect was introduced in 1926 by Oskar Klein [17, 18]. A summary on the temporary development was published in 1987 by Appelquist, Chodos and Freund titled "Modern Kaluza-Klein Theories" [19]. In 1999 another summary [20] was published with a similar title by Paul Wesson. The update came in 2019 [21].

One of the focal points of many papers dealing with Kaluza-Klein theories concentrate on the inclusion of electromagnetism in 5-dimensional space-time. These developments frequently involve the construction of a 5-dimensional line element and the composition of the respective Einstein tensor. Higher dimensional approaches come with string theory [22-24]. While string theory introduces a rich mathematical methodology, it is unable to deliver results that can be compared with data gathered from experiments. The Standard Model comes with the quantum structure of elementary particles which is capable of calculating the decay probabilities of particles [25]. However, a general method for calculating hadron masses is still lacking [26, 27]. In addition, in order to describe the features and capabilities, a method should be found within the framework of a multi-dimensional space-time in which to portray particle physics.

Is it reasonable to exchange the robust Standard Model for something that so far has been able to describe gravitation very well while at the same time be unable to contribute to the very small, particle physics? And is it possible that the Standard Model and a multidimensional relativity both be meaningful and able to produce results? More precisely, what if both approaches represent two sides of the same coin, such as in the sense of dualism? The famous double slit experiment [28] that displays wave and particle nature at the same time points towards such a possibility. Therefore, within this article a model is introduced which describes the outlines of the Standard Model in terms of a "Kaluza-Klein like theory": an approach for looking at the Standard Model from a different perspective, and not as a contradictory method.

The following development consists of ten deformable dimensions: one time, three macroscopic space and another 6 compactified space dimensions. Within all dimensions, an excitation, a temporary deformation of this 10-dimensional canvas, can always move with the speed of light. In the usual 4D space, an excitation is identified as a gravitational wave. In a compactified dimension, a stable excitation has a well-defined length, depending on the dimension's radius. The actual radii of the six compactified dimensions are able to change dynamically depending on the specific excitations, which are identified as particles. During the development of the model, the explicit space-time structure is given. The next step is an explanation of the three interactions and the corresponding formulas for calculating particle masses. The particles are identified in terms of the 6 compactified dimensions. Afterwards, the model's free constants are determined; the most important are the compactification radius ρ, the weak coupling α_w, the strong coupling α_s and the neutrino z_ν to anti-neutrino $z_{\bar{\nu}}$ distribution ratio δ. For this purpose, the measured masses of the leptons, the mesons π^0, π^+, ρ^0, ϕ, ψ, Υ, the top-quark mass (as given by the Particle Data Group [29]) and the magnetic moment of the electron are used. From here onwards, there are no more free parameters available. Then, the calculation rules for the pseudo-scalar and vector mesons; and for the spin 3/2 and 1/2 baryons are stated. The masses of approximately 100 hadrons will be calculated and compared with the experimental data, if available. The relative error between the measured and the calculated mass is < 0.05 for most of the comparable hadrons.

Model

Embedding and container space

The start point is a 10-dimensional space consisting of 1 time and 9 space dimensions. The time and three space dimensions constitute the usual space-time. The other six space dimensions are compact dimensions. For calculational reasons, this ten-dimensional space is embedded within a 20-dimensional container space. The connections between the physical 10D space x^i and the container space y^j is given as:

$$\begin{aligned} y^0 &= ct \\ y^1 &= x^1 \\ y^2 &= x^2 \\ y^3 &= x^3 \\ y^i &= r^i \cdot \cos(\varphi_i) = r^i \cdot \cos\left(\frac{x^i}{r^i}\right) \\ y^{10} &= 0 \\ y^{11} &= 0 \\ y^{12} &= 0 \\ y^{13} &= 0 \\ y^{i+10} &= r^i \cdot \sin(\varphi_i) = r^i \cdot \sin\left(\frac{x^i}{r^i}\right) \end{aligned} \tag{1}$$

As such, r^i is the radius of the compact dimension with indices $i = 4,5,6,7,8,9$. The container space has a simple flat metric of the form

$$\eta_{ab} = diag(1,-1,-1,1,-1 \cdots,-1) \tag{2}$$

with a and b from 0 to 19 and $\eta_{00} = \eta_{1010} = 1$.

The connection between the 10-dimensional physical space and the 20-dimensional container space is given as

$$g_{\mu\nu} = \frac{\partial y^a}{\partial x^\mu}\frac{\partial y^b}{\partial x^\nu}\eta_{ab} \tag{3}$$

The 6 additional compactified dimensions are subdivided into sections for the purpose of: the strong interaction – dimensions 4 to 6 -; the electric interaction – dimension 7 -; and, the weak interaction – dimensions 8 and 9.

The angular momentum of a stable excitation on a compatified dimension

A particle is a combination of associated excitations, which waves around some of the six compact tubes forming one unit. The signal velocity around a tube is always c, the speed of light. A full revolution around a tube (double value) is

$$4\pi r^i = n^i \lambda^i \tag{4}$$

with n^i being an integer. The wavelength is connected to the speed of light and the frequency ν in the usual way.

$$c = \nu \cdot \lambda \tag{5}$$

The momentum of an excitation is

$$p^i = \hbar k^i \tag{6}$$

whereby $k^i = {2\pi}/{\lambda^i}$ is the wave vector. With these definitions, the spin (angular momentum) of an excitation on one tube is

$$s^i = r^i \times p^i = r^i \times \frac{2\pi\hbar}{\lambda^i} = r^i \times \frac{n^i\hbar}{2r^i} = n^i \frac{\hbar}{2} \tag{7}$$

, independent of the tube radius.

The electric interaction – dimension 7

The start of the development is a point-particle current (as seen in the usual 4D space) of four-velocity w^μ

$$J_e^\mu = \frac{e}{3} \cdot o \cdot \delta^3(\vec{x} - \vec{y}) \cdot w^\mu \tag{8}$$

and the covariant Liénard-Wiechert potential [30] caused by a point-particle of four-velocity v^μ.

$$A_e^\mu = \frac{\frac{e}{3} \cdot n}{4\,\pi\,\varepsilon_0\,c^2} \cdot \frac{v^\mu}{|\vec{y} - \vec{x}_0|} \tag{9}$$

The potential energy between these two particles is:

$$U_{no}^e(|\vec{x} - \vec{x}_0|) = \iiint_{-\infty}^{\infty} J_e^\mu A_\mu^e \, dy_1\, dy_2\, dy_3 \tag{10}$$

$$= \frac{e^2\, n\, o}{4\,\pi\,\varepsilon_0\, c^2\, 9} \cdot \frac{w^\mu v_\mu}{|\vec{x} - \vec{x}_0|} = \frac{\alpha_e c\hbar n o\, f_{no}(z)}{9\,\rho\, z}$$

Here $|\vec{x} - \vec{x}_0|$ is abbreviated as $\rho \cdot z$, with a constant ρ of dimension length, and a dimensionless parameter z. In addition, the invariant expression is condensed as:

$$w^\mu v_\mu = c^2\, \gamma_o\, \gamma_n\, g_{\mu\nu} \beta_o^\mu \beta_n^\nu = c^2\, f_{no}(z) \tag{11}$$

As such $f_{no}(z)$ contains all z-depended parts of the expression. In particular, this includes the metric tensor $g_{\mu\nu}(z)$, and the normalized velocity $\beta = \frac{v(z)}{c}$, as well as $\gamma = \frac{1}{\sqrt{1-\beta^2}}$. The force on such a particle is

$$\vec{F}_e(z) = -\frac{1}{\rho} \cdot \frac{\partial}{\partial z} \frac{\alpha_e c\hbar n o\, f_{no}(z)}{9\,\rho\, z} = \frac{\alpha_e c\hbar n o\, f_{no}(z)}{9\,\rho^2\, z^2} - \frac{\alpha_e c\hbar n o \frac{\partial f_{no}(z)}{\partial z}}{9\,\rho^2\, z} \tag{12}$$

The energy of the excitation o is

$$E_o^e(z) = \left(\hbar\omega(r_o) + \frac{A\alpha_e c\hbar}{9\rho}\right) \cdot \gamma_o(z) = \left(\frac{oc\hbar}{r_o(z)} + \frac{A\alpha_e c\hbar}{9\rho}\right) \cdot \gamma_o(z) \tag{13}$$

in which the second term represents a constant, multiplied by the γ_o-factor. The resultant force is

$$-\frac{1}{\rho}\cdot\frac{\partial}{\partial z}E_o^e(z)=-\frac{1}{\rho}\cdot\left(\frac{oc\hbar}{r(z)}+\frac{A\alpha_e c\hbar}{9\rho}\right)\cdot\frac{\partial\gamma_o(z)}{\partial z}+\frac{oc\hbar}{\rho r^2}\cdot\frac{\partial r}{\partial z}\cdot\gamma_o(z) \tag{14}$$

In order to describe the same force, the equations (12) and (14) are used to calculate the tube radius of dimension 7 (with o and n being the excitation numbers), which are written with the respective index from here on.

$$r_{o_7}(z)=-\frac{9\,\gamma_o(z)\,\rho\,z\,o_7}{A\,\alpha_e\,\gamma_o(z)\,z-\alpha_e\,n_7\,o_7\,f_{no}(z)-9\,C\,\rho\,z\,o_7} \tag{15}$$

The limit of the undisturbed radius at infinity is

$$\lim_{z\to\infty} r_{o_7}=-\frac{9\,\rho\,o_7}{A\,\alpha_e-\;9\,C\,\rho\,o_7}=\frac{9\,signum(o_7)\cdot\rho}{\alpha_e} \tag{16}$$

hence allowing to fix the free constant C as:

$$C=\frac{\alpha_e\,(A+|o_7|)}{9\,o_7\,\rho} \tag{17}$$

Here ρ is identified as the compactification radius, which will be calculated later. The radius of equation (15) becomes

$$r_{o_7}(z)=\frac{9\,\gamma_o(z)\rho\,o_7}{\alpha_e\cdot\left(\frac{n_7\,o_7\,f_{no}(z)}{z}+A\,\left(1-\,\gamma_o(z)\right)+|o_7|\right)} \tag{18}$$

The energy generated via the electric interaction of the particle is achieved by inserting (18) into equation (13).

$$E_{o_7}^e(z)=\left(\frac{oc\hbar}{r_o(z)}+\frac{A\alpha_e c\hbar}{9\rho}\right)\cdot\gamma_o(z)=\frac{\alpha_e\,c\,\hbar}{9\,\rho}\cdot\left(\frac{n_7\,o_7\,f_{no}(z)}{z}+A+|o_7|\right) \tag{19}$$

Equation (19) describes a combination of rest and kinetic energy. To achieve full energy, the potential energy, the negative of (10), must be added. The observable mass becomes

$$m_{o_7}=\frac{E_{o_7}^e(z)-U_{no}^e(z)}{c^2}=\frac{\alpha_e\hbar\cdot(A+|o_7|)}{9c\rho} \tag{20}$$

, which is not dependent on z.

The strong interaction – dimensions 4, 5, and 6

At this point the color representation is introduced as:

$$c_{red}=\begin{pmatrix}1\\-1\\0\end{pmatrix}\quad c_{green}=\begin{pmatrix}0\\1\\-1\end{pmatrix}\quad c_{blue}=\begin{pmatrix}-1\\0\\1\end{pmatrix} \tag{21}$$

For an anti-color each component is multiplied by -1. The calculations of the tube radii are done analog to the electric case. Again, starting with a point-particle current of four-velocity w^μ for each dimension the current is

$$J_s^\mu=e_s\cdot\delta^3(\vec{x}-\vec{y})\cdot w^\mu\,n_i \tag{22}$$

and the vector potential (simplified ansatz form [31-34]) depending linearly on the distance between the two color charges,

$$A_s^\mu=\frac{e_s}{4\,\pi\,\varepsilon_s\,c^2}\cdot\frac{|\vec{y}-\vec{x}_0|}{\rho^2}v^\mu o_i=\frac{e_s}{4\,\pi\,\varepsilon_s\,c^2}\cdot\frac{z}{\rho}v^\mu o_i \tag{23}$$

the potential energy between these two particles is calculated in the usual way.

$$\begin{aligned}U_{no}^s(z)&=\iiint_{-\infty}^{\infty}J_s^\mu A_\mu^s\,dy_1\,dy_2\,dy_3\\&=\frac{e_s^2\,n\,o}{4\,\pi\,\varepsilon_s\,c^2}\cdot w^\mu v_\mu\cdot n_i\,o_i\cdot\frac{z}{\rho}\\&=\frac{\alpha_s c\hbar\,n_i\,o_i}{\rho}\cdot f_{no}(z)\cdot z\end{aligned} \tag{24}$$

The force becomes:

$$\vec{F}_s = -\frac{1}{\rho}\cdot\frac{\partial}{\partial z}U_{no}^{s}(z) \tag{25}$$
$$= -\frac{\alpha_s c\hbar\, n_i\, o_i}{\rho^2}\cdot\left(\frac{df_{no}(z)}{dz}\cdot z + f_{no}(z)\right)$$

The energy of a tube is:

$$E_o^s(z) = \left(\frac{o_i c\hbar}{r_o(z)} + \frac{\alpha_s c\hbar\, A}{\rho}\right)\cdot\gamma_o(z) \tag{26}$$

and the associated force is:

$$-\frac{1}{\rho}\cdot\frac{\partial}{\partial z}E_o^s(z) = -\frac{1}{\rho}\cdot\left(\frac{o_i c\hbar}{r_o(z)} + \frac{\alpha_s c\hbar\, A}{\rho}\right)\cdot\frac{\partial\gamma_o(z)}{\partial z} + \frac{o_i c\hbar\gamma_o(z)_o}{\rho r_o^2(z)}\cdot\frac{\partial r_o}{\partial z} \tag{27}$$

Using the two equations (25) and (27) as in the electric case, allows one to calculate the radius of the color tubes ($i = 4, 5, 6$).

$$r_{o_i}(z) = \frac{\rho\, o_i\, \gamma_o(z)}{\alpha_s\, n_i\, o_i\, f_{no}\, z + C\,\rho\, o_i - \alpha_s\, A\,\gamma_o(z)} \tag{28}$$

Fixing the free constant is archived via:

$$\lim_{z\to 0} r_{o_i} = \frac{o_i\,\rho}{o_i\,\rho\, C - \alpha_s\, A_o} = \frac{signum(o_i)\,\rho}{\alpha_s} \tag{29}$$

with the result:

$$C = \frac{\alpha_s(A + |o_i|)}{o_i\,\rho} \tag{30}$$

The tube radius becomes:

$$r_{o_i}(z) = \frac{\rho\, o_i\, \gamma_o(z)}{\alpha_s\left(o_i\, n_i\ f_{no}(z)\cdot z + A(1-\gamma_o(z)) + |o_i|\right)} \tag{31}$$

At this point, without the potential energy, the color energy becomes

$$E_{o_i}^s(z) = \frac{\alpha_s c\hbar}{\rho}(A +\ |o_i| + n_i o_i\cdot f_{no}\cdot z) \tag{32}$$

Finally, the color mass is

$$m_{o_i} = \frac{E_{o_i}^s(z) - U_{no}^s(z)}{c^2} = \frac{\alpha_s\hbar}{c\,\rho}\cdot(A + |o_i|) \tag{33}$$

The weak interaction – dimensions 8 and 9

The point-particle currents of the weak interaction is

$$J_w^\mu = e_F\cdot\delta^3(\vec{x}-\vec{y})\cdot w^\mu\, n_i \tag{34}$$

In the electric case, the vector potential shows a $1/z$ dependence. For the strong interaction the vector potential has a z dependency. The electric interaction needs one dimension while the strong interaction occupies three dimensions. The weak interaction uses two dimensions. Therefore, the conjecture for the weak vector potential is a logarithmic dependence since this appears to be the plausible functional behavior for this number of dimensions. However, a screening effect must play a role here, too. Every particle reacting to the weak interaction is also affected by the nearby neutrinos and anti-neutrinos. This means that besides the interaction with a specific second particle, there is an additional contribution of nearby neutrinos and anti-neutrinos.

$$A_w^\mu = \frac{e_F}{4\,\pi\,\varepsilon_w\, c^2}\cdot\frac{v^\mu}{\rho}o_i\left[n_i\cdot ln(z) - ln(z_\nu) + ln(z_{\bar{\nu}})\right] \tag{35}$$
$$= \frac{e_F}{4\,\pi\,\varepsilon_w\, c^2}\cdot\frac{v^\mu}{\rho}o_i\left[n_i\cdot ln(z) - ln(\delta)\right]$$

Here, δ is equal to the distance of the nearest neutrino z_ν compared to the distance of the nearest anti-neutrino $z_{\bar{\nu}}$. It is also equal to the cubic root of the anti-neutrino density $\rho_{\bar{\nu}}$ devided by the neutrino density ρ_{ν}. For a homogeneous density, this connection is for any given volume $V = n_\nu\, z_\nu^3\, \rho^3 = n_{\bar{\nu}}\, z_{\bar{\nu}}^3\, \rho^3$

$$\frac{\rho_{\bar{\nu}}}{\rho_\nu} = \frac{n_{\bar{\nu}}}{V} \cdot \frac{V}{n_\nu} = \frac{n_{\bar{\nu}}\, n_\nu\, z_\nu^3\, \rho^3}{n_\nu\, n_{\bar{\nu}}\, z_{\bar{\nu}}^3\, \rho^3} = \frac{z_\nu^3}{z_{\bar{\nu}}^3} = \delta^3 \tag{36}$$

This establishes the neutrino z_ν to anti-neutrino $z_{\bar{\nu}}$ rate

$$\delta = \frac{z_\nu}{z_{\bar{\nu}}} = \left(\frac{\rho_{\bar{\nu}}}{\rho_\nu}\right)^{\frac{1}{3}} \tag{37}$$

The associated potential energy as previously demonstrated

$$\begin{aligned} U_{no}^w(z) &= \iiint_{-\infty}^{\infty} J_w^\mu A_\mu^w\, dy_1\, dy_2\, dy_3 \\ &= \frac{e_F^2}{4\,\pi\,\varepsilon_w\, c^2} \cdot \frac{w^\mu v_\mu}{\rho}\; o_i\, [n_i \cdot ln(z) - ln(\delta)] \\ &= \alpha_w \cdot \frac{c\,\hbar\, o_i\, f_{no}(z)}{\rho} \cdot [n_i \cdot ln(z) - ln(\delta)] \end{aligned} \tag{38}$$

with the force

$$\begin{aligned} \vec{F}_w &= -\frac{1}{\rho} \cdot \frac{\partial}{\partial z} U_{no}^w(z) \\ &= -\frac{\alpha_w c\hbar\, o_i}{\rho^2} \cdot \left([n_i \cdot ln(z) - ln(\delta)] \cdot \frac{\partial f_{no}(z)}{\partial z} + n_i \cdot \frac{f_{no}(z)}{z} \right) \end{aligned} \tag{39}$$

The tube energy is

$$E_{o_i}^w(z) = \left(\frac{o_i c\hbar}{r_{o_i}(z)} + \frac{\alpha_w c\hbar A}{\rho}\right) \cdot \gamma_o(z) \tag{40}$$

The force becomes

$$-\frac{1}{\rho} \cdot \frac{\partial}{\partial z} E_{o_i}^w(z) = -\frac{1}{\rho} \cdot \left(\frac{oc\hbar}{r_{o_i}(z)} + \frac{\alpha_w c\hbar A}{\rho}\right) \cdot \frac{\partial \gamma_o(z)}{\partial z} + \frac{oc\hbar\gamma_o(z)}{\rho r_{o_i}^2(z)} \cdot \frac{\partial r_o}{\partial z} \tag{41}$$

Once again, combining the two forces (39) and (41) into one equation allows for calculating the tubes' radii with the result

$$r_{o_i}(z) = \frac{o_i\, \rho\, \gamma_o(z)}{\alpha_w\, o_i\, [ln(z) \cdot n_i - ln(\delta)] \cdot f_{no}(z) + C\, \rho\, o_i - A\, \alpha_w\, \gamma_o(z)} \tag{42}$$

for $i = 8{,}9$. The fixing of the free constant

$$\lim_{z \to 1} r_{o_i} = \frac{o_i\, \rho}{-\alpha_w o_{\,i}\, ln(\delta) + C\, \rho\, o_i - \alpha_w\, A} = \frac{signum(o_i) \cdot \rho}{\alpha_w} \tag{43}$$

results in

$$r_{o_i}(z) = \frac{\rho\, o_i\, \gamma_o(z)}{\alpha_w \left(o_i \cdot [1 - f_{no}(z)]\, ln(\delta) + ln(z)\, f_{no}(z) \cdot n_i\, o_i + A\, \left(1 - \gamma_o(z)\right) + |o_i|\right)} \tag{44}$$

The overall distribution of neutrinos and anti-neutrinos expressed though δ, provides a very small contribution to a particle's energy

$$\begin{aligned} E_{o_i}(z) &= \frac{\alpha_w c\hbar}{\rho} \cdot \left([1 - f_{no}(z)]\, o_i\, ln(\delta) + f_{no}(z)\, ln(z)\, n_i\, o_i + |o_i| + A\right) \\ &= \frac{\alpha_w c\hbar}{\rho} \cdot \left(o_i\, ln(\delta) + f_{no}(z)\, o_i\, [ln(z)\, n_i - ln(\delta)] + |o_i| + A\right) \end{aligned} \tag{45}$$

Once again, the mass becomes

$$m_{o_i} = \frac{E_{o_i n_i}(z) - U_{no}^w(z)}{c^2} = \frac{\alpha_w \hbar}{c\,\rho} \cdot \left([1 + signum(o_i)\, ln(\delta)] \cdot |o_i| + A\right) \tag{46}$$

The particle mass of strong, electric, and weak interaction

For all the additional dimensions – the three interactions strong, electric, and weak – the total mass m_o, without the contribution of magnetism, of a particle is

$$m_o = \frac{\hbar}{c\rho} \cdot \left[\alpha_s\left(|o_4| + |o_5| + |o_6|\right) + \frac{\alpha_e |o_7|}{9} + \alpha_w \sum_{i=8}^{9} \left(\left[1 + signum(o_i)\, ln(\delta)\right] \cdot |o_i| \right) \right] + \frac{\hbar\, A}{c\rho} \cdot \left[3\, \alpha_s + \frac{\alpha_e}{9} + 2\, \alpha_w \right] \quad (47)$$

Masses depending solely on the weak sector

The situation differs somewhat for particles that are effected exclusively by the weak interaction. The potential energy, after being created together with other particles, depends on the average $\nu/\bar{\nu}$ distribution only, and the equation (38) reduces to

$$U_{o_i}^{w}(z) = -\frac{\alpha_w \cdot c\, \hbar\, o_i\, ln(\delta) \cdot f_{no}(z)}{\rho} \quad (48)$$

The force is

$$\vec{F}_w = -\frac{1}{\rho} \cdot \frac{\partial}{\partial z} U_{no}^{w}(z) = \frac{\alpha_w \cdot c\, \hbar\, o_i\, ln(\delta)}{\rho^2} \cdot \frac{\partial f_{no}(z)}{\partial z} \quad (49)$$

The energy of the excitation has the identical structure as for the general weak interaction (40). Continuing the above-mentioned procedure and including the adjustment of the free constant through:

$$\lim_{z \to 1} r_{o_i} = -\frac{\rho\, o_i}{\alpha_w\, o_i\, ln(\delta) - C\, \rho\, o_i + \alpha_w\, A} = \frac{\rho}{\alpha_w \cdot ln(\delta)} \quad (50)$$

, the varying tube radius becomes

$$r_{o_i}(z) = \frac{o_i\, \rho\, \gamma_o(z)}{\alpha_w\left(o_i\, [2 - f_{no}(z)] \cdot ln(\delta) + A\, [1 - \gamma_o(z)]\right)} \quad (51)$$

, which then results in the excitation energy

$$E_{o_i}(z) = \frac{\alpha_w c\hbar}{\rho} \cdot \left(o_i\, [2 - f_{no}(z)] \cdot ln(\delta) + A\right) \quad (52)$$

The mass becomes ($i = 8{,}9$)

$$m_{o_i} = \frac{E_{o_i}(z) - U_{o_i}^{w}(z)}{c^2} = \frac{\alpha_w \hbar}{c\rho}\left(2\, o_i\, ln(\delta) + A\right) \quad (53)$$

Calculation of particle velocity, acceleration, and force

In the usual four-dimensional space-time with $u^\alpha = \gamma\beta^\alpha c$, the expression

$$u^\alpha u_\alpha = c^2 \quad with \quad \alpha = 0{,}1{,}2{,}3 \quad (54)$$

is conserved. The 10-dimensional version has the form of:

$$u^\mu u_\mu = (1 - n)\, c^2 = -5\, c^2 \qquad \mu = 0{,}1{,}2{,}3, \ldots, 9 \quad (55)$$

With $n = 6$, the number of additional dimensions is indexed 4 to 9. For a coordinate system, with the two particles located on the z^1-axis and $z^2 = z^3 = 0$, the velocity can be calculated as a function of the distance between the particles. By means of the metric tensor of equation (3), the calculation of the Christoffel symbols can be performed in the usual way.

$$\Gamma_{\nu\xi}^{\mu} = \frac{1}{2} g^{\mu\kappa}\left(\partial_\nu g_{\kappa\xi} + \partial_\xi g_{\kappa\nu} - \partial_\kappa g_{\nu\xi}\right) \quad (56)$$

The acceleration is calculated by means of the geodesic equation.

$$a^\mu = -\Gamma_{\nu\xi}^{\mu} u^\nu u^\xi = -c^2 \Gamma_{\nu\xi}^{\mu} \beta^\nu \beta^\xi \quad (57)$$

The force is established as:

$$F^{\mu}(z) = \frac{E_o(z)}{c^2}\,\gamma\, a^{\mu} \tag{58}$$

with $\gamma = 1/\sqrt{1-\beta^2}$.

First example: Calculating the Coulomb force between two slow moving charges

The electric force between two charges $q_1 = \frac{e}{3} \cdot o_7$ and $q_2 = \frac{e}{3} \cdot n_7$ of first generation particles – $A = 0$, which will be shown below - is calculated for slow movement $\beta \cong 0$. The radius (18) reduces to:

$$r_{o_7}(z) = \frac{9\,\rho\; signum(o_7)}{\alpha_e \cdot \left(1 + \frac{n_7\; signum(o_7)}{z}\right)} \tag{59}$$

The mass $E^e_{o_7}(z)/c^2$ associated with equation (19) is used, whereby within this expression β and γ are still included. While the full solution of (58) is rather long, the first terms of the series in ρ are manageable.

$$F^1(R) = \frac{\alpha_e\, c\, \hbar\, o_7\, n_7}{9\, R^2} + \frac{18\, n_7^2\, |o_7|\, c\, \hbar\, \beta^2\, \gamma^2}{\alpha_e\, R^5} \cdot \rho^3 + O(\rho^4) \tag{60}$$

$R = \rho \cdot z$ is the distance in meters. ρ is of the order of femtometer as shown below. For distances above $10^{-13} m$, the first term of (60) is dominant, and represents the well-known formula of the Coulomb force of electrostatics.

Calculation of the model’s constants

The compactification radius ρ

The undisturbed radius of the electric tube is ${}^{9\rho}/_{\alpha_e}$. The time for an electron excitation (of length $\lambda = 4\pi r/3$ and velocity c) to revolve around the tube is:

$$\Delta T = \frac{3\,\lambda}{c} = \frac{4\pi r}{c} = \frac{36\pi\rho}{\alpha_e c} \tag{61}$$

With this, the electric current calculates as:

$$I = -\frac{e}{\Delta T} = -\frac{e\alpha_e c}{36\,\pi\rho} \tag{62}$$

The classic magnetic dipole moment is defined (n=2 being the winding number, A is the area the current flows around) as:

$$\mu = n\, I\, A = -2 \cdot \frac{e\alpha_e c}{36\,\pi\rho} \cdot \pi \cdot \frac{81\rho^2}{\alpha_e^2} = -\frac{9ec\rho}{2\alpha_e} \tag{63}$$

The magnetic dipole moment of an electron - electric dimension’s spin $S_e = 3\hbar/2$ - is:

$$\mu_S = -\frac{g\mu_B S_e}{\hbar} = -\frac{3ge\hbar}{4m_e} \tag{64}$$

Comparing these two expressions gives the value of the compactification radius ρ by using the measured magnetic moment $g = 2.00231930436182(52)$ as:

$$\rho = \frac{g\hbar\alpha_e}{6m_e c} = 9.4040252(14) \cdot 10^{-16} m \tag{65}$$

The weak coupling α_w and the neutrino distribution ratio δ

The mass of the three leptons e, μ, τ are calculated according to equation (47):

$$m_{e,\mu,\tau} = \frac{\hbar}{c\rho} \cdot \left[\frac{\alpha_e}{3} + 2\,\alpha_w\,(1 + \,ln(\delta)\,)\right] + \frac{\hbar\, A_{e,\mu,\tau}}{c\rho} \cdot \left[3\alpha_s + \frac{\alpha_e}{9} + 2\,\alpha_w\right] \tag{66}$$

The couplings for the strong α_s, the weak interaction α_w, and the constant δ are at this point not yet known. But solving the equation (66) for A_e and setting in the numbers of the known values, results in:

$$A_e = \frac{0.00002538274 - 18\,\alpha_w \cdot (1 + ln(\delta))}{27\,\alpha_s + 0.007297352536 + 18\,\alpha_w} \tag{67}$$

It is known that α_s [35] is in the order of one and α_w [36] is about 10^{-6}, while δ is almost one, which results in $ln(\delta)$ being close to zero. It shows $A_e < 10^{-6}$ as being very small. So, the first term of (66) is approximately three orders of magnitude larger than term two. This suggests that A_e is exactly zero, and in the wake of it all, $A's$ of the first generation are presumed to be zero. There is a second argument supporting the accuracy. Later in this article the higher dimensional structure of the photon will be deduced. For the photon to be massless $A_{first\ generation} = 0$ must hold true. From here onward the calculations will be done accordingly: $A_e = A_{\nu_e} = A_d = A_u = 0$.

The mass of an electron becomes (see equation (47)) for the electric mass contribution and the weak mass part:

$$m_{e^-} = \frac{\hbar}{c\,r_e(R=\infty)} + \frac{\hbar}{c\,r_w} = \frac{\hbar}{c\rho}\left[\frac{\alpha_e}{3} + 2\alpha_w \cdot (1 + 2\,ln(\delta))\right] \tag{68}$$

The positron is

$$m_{e^+} = \frac{\hbar}{c\,r_e(R=\infty)} + \frac{\hbar}{c\,r_w} = \frac{\hbar}{c\rho}\left[\frac{\alpha_e}{3} + 2\alpha_w \cdot (1 - 2\,ln(\delta))\right] \tag{69}$$

The upper limit for the mass difference [29, 37] between a positron and an electron is $\frac{|m_{e^+} - m_{e^-}|}{m_{average}} < 8 \cdot 10^{-9}$. With the electron mass and the small mass difference, it is possible to calculate the weak coupling α_w and estimate δ.

$$\alpha_w = \frac{3\,c\,\rho\,m_{average} - \hbar\,\alpha_e}{6\,\hbar} = 1.41040(26) \cdot 10^{-6} \tag{70}$$

$$\delta = \exp\left(\frac{c\,\rho\,m_{average} \cdot 8 \cdot 10^{-9}}{4\,\hbar\,\alpha_e}\right) = \begin{cases} 1.0000034530(64) & \text{if } m_{e^+} < m_{e^-} \\ 0.9999965467(64) & \text{if } m_{e^+} > m_{e^-} \end{cases} \tag{71}$$

To complete the list of constants in terms of the leptons with electric charge, the measured masses of the muon and the tau plus equation (66) are used to calculate the lepton constants (**Table 1**).

Table 1: Values of the lepton constants

$A_e = 0$	$A_\mu = 0.33561(26)$	$A_\tau = 5.6698(44)$
$A_{\nu_e} = 0$	$A_{\nu_\mu} = \text{unknown}$	$A_{\nu_\tau} = \text{unknown}$

The strong coupling α_s and the magnetic self-interaction within the mesons

By means of equation (47), the strong, electric, and weak mass ratios of the quarks, can be stated.

$$m_{d,s,b} = \frac{\hbar}{c\,\rho}\left[2\alpha_s + \frac{1}{9}\alpha_e + 2\,\alpha_w \cdot (1 + \ln(\delta))\right] + \frac{\hbar\,A_{d,s,b}}{c\rho} \cdot \left[3\alpha_s + \frac{\alpha_e}{9} + 2\,\alpha_w\right] \tag{72}$$

$$m_{\bar{d},\bar{s},\bar{b}} = \frac{\hbar}{c\,\rho}\left[2\alpha_s + \frac{1}{9}\alpha_e + 2\,\alpha_w \cdot (1 - \ln(\delta))\right] + \frac{\hbar\,A_{d,s,b}}{c\rho} \cdot \left[3\alpha_s + \frac{\alpha_e}{9} + 2\,\alpha_w\right] \tag{73}$$

$$m_{u,c,t} = \frac{\hbar}{c\,\rho}\left[2\alpha_s + \frac{2}{9}\alpha_e + \alpha_w \cdot (1 - ln(\delta))\right] + \frac{\hbar\,A_{u,c,t}}{c\rho} \cdot \left[3\alpha_s + \frac{\alpha_e}{9} + 2\,\alpha_w\right] \tag{74}$$

$$m_{\bar{u},\bar{c},\bar{t}} = \frac{\hbar}{c\,\rho}\left[2\alpha_s + \frac{2}{9}\alpha_e + \alpha_w \cdot (1 + ln(\delta))\right] + \frac{\hbar\,A_{u,c,t}}{c\rho} \cdot \left[3\alpha_s + \frac{\alpha_e}{9} + 2\,\alpha_w\right] \tag{75}$$

The differences of the quark masses are not caused exclusively by the strength of the interaction itself (first term), rather it is strongly induced by the constant represented by the second term. As previously mentioned, all constants of the first generation are treated as zero $A_e = A_{\nu_e} = A_d = A_u = 0$. Not including the magnetic self-interaction, the first generation meson masses $\widetilde{m}$ become:

$$\widetilde{m}_{\pi^0} = \frac{\widetilde{m}_{d\bar{d}} + \widetilde{m}_{u\bar{u}}}{2} = \frac{m_d + m_{\bar{d}}}{2} + \frac{m_u + m_{\bar{u}}}{2} = \widetilde{m}_{\rho^0} \qquad (76)$$
$$\widetilde{m}_{\pi^+} = \widetilde{m}_{u\bar{d}} = m_u + m_{\bar{d}} = \widetilde{m}_{\rho^+}$$

Each of the quarks and anti-quarks represents a dipole and possesses a magnetic field as well. The energy of a dipole $\vec{\mu}$ within a magnetic field is written as

$$U_{dipole} = -\vec{\mu} \cdot \vec{B} = \frac{-M \cdot c^2 \cdot o_7 \cdot n_7}{m} \quad with \quad \mu \sim \frac{o_7}{m} \quad and \;\; B \sim n_7 \qquad (77)$$

, which is rewritten as a thus unknown constant M multiplied by the electric excitation numbers of the two quarks. The energy of one quark's magnetic field within a given volume is

$$U_B = \frac{B^2}{2\,\mu_0} = N \cdot c^2 \cdot o_7^2 \qquad (78)$$

, which is written as the constant N multiplied by the excitation number squared. In combination with the other quarks, the magnetic fields must first be combined in order to calculate the magnetic energy of a meson or baryon. The meaning of the symbols is $\vec{B}$: magnetic field, o: excitation number of quark one; n: excitation number of quark two; and m: particle mass. The mass contributions due to magnetism for mesons and baryons differ. For mesons, it can be stated as

$$m_{q\bar{q}} = m_q + m_{\bar{q}} + m_{q\bar{q}}^B + \begin{cases} -\left|m_q^{dipole} + m_{\bar{q}}^{dipole}\right| & \text{for scalar mesons} \\ +\left|m_q^{dipole} + m_{\bar{q}}^{dipole}\right| & \text{for vector mesons} \end{cases} \qquad (79)$$

The dipole masses for pseudo scalar mesons are all negative, which reduces their mass. For vector mesons dipole masses are positive with a mass increasing effect. In addition, there are differences in calculating magnetic contributions for pseudo scalar or vector mesons. The commonalities of all the calculations for mesons and baryons alike is – starting with parallel spin orientation - a spin flip causes a quark's or anti-quark's excitation number to be multiplied by -1. Hence, the calculation rule for a scalar meson is:

$$m_{q\bar{q}}^B = N \cdot (o_7 - n_7)^2 \qquad m_q^{dipole} = -\frac{M}{m_q} \cdot [o_7 \cdot (-n_7)] \qquad m_{\bar{q}}^{dipole} = -\frac{M}{m_{\bar{q}}} \cdot [(-n_7) \cdot o_7] \qquad (80)$$

, while for a vector meson, the calculation is:

$$m_{q\bar{q}}^B = N \cdot (o_7 + n_7)^2 \qquad m_q^{dipole} = -\frac{M}{m_q} \cdot [o_7 \cdot n_7] \qquad m_{\bar{q}}^{dipole} = -\frac{M}{m_{\bar{q}}} \cdot [n_7 \cdot o_7] \qquad (81)$$

Now it is possible to state the mass formulas for the first-generation mesons.

$$m_{\pi^0} = \frac{m_d + m_{\bar{d}} + m_u + m_{\bar{u}}}{2} + \frac{1}{2} \cdot \left(20\,N - \frac{M}{m_d} - \frac{M}{m_{\bar{d}}} - \frac{4\,M}{m_u} - \frac{4\,M}{m_{\bar{u}}}\right) \qquad (82)$$
$$m_{\pi^+} = m_u + m_{\bar{d}} + N - \frac{2\,M}{m_u} - \frac{2\,M}{m_{\bar{d}}}$$
$$m_{\rho^0} = \frac{m_d + m_{\bar{d}} + m_u + m_{\bar{u}}}{2} + \frac{1}{2} \cdot \left(\frac{M}{m_d} + \frac{M}{m_{\bar{d}}} + \frac{4\,M}{m_u} + \frac{4\,M}{m_{\bar{u}}}\right)$$
$$m_{\rho^+} = m_u + m_{\bar{d}} + 9N + \frac{2\,M}{m_u} + \frac{2\,M}{m_{\bar{d}}}$$

By using the measured masses of the mesons π^0, π^+ and ρ^0 [29] along with the respective mass formulas of (82), it is possible to calculate the numerical values of the magnetic multipliers and the strong coupling (**Table 2**).

Table 2: The magnetic multiplier values and the strong coupling

$M = 4.74681(57) \cdot 10^{-56} kg^2$	$N = 1.323(10) \cdot 10^{-29} kg$	$\alpha_s = 0.49743(39)$

Particle identification

The identification of the fermions is straight forward. Color and electric charge are easily set. A quark comes with one of the colors: red, green or blue, and the respective excitation numbers. The electric excitation number is minus one for a down quark, two for an up quark and minus three for an electron. Each excitation number adds up a spin $\hbar/2$ times excitation number. To get an overall spin $\hbar/2$, the weak excitations adjust respectively. A neutrino has weak excitations, only. This particle comes as a superposition of the weak excitations. Hence, the excitation number formally written as ½, is the same as for the weak contribution of an u-quark (**Table 3**).

Table 3: Fermions of the first generation

Particle	r_4 strong	r_5 strong	r_6 strong	r_7 electric	r_8 weak	r_9 weak	Mass formula of electric, strong, and weak interaction without the contribution of magnetism
electron	0	0	0	-3	1	1	$m_e = \frac{\hbar}{c\rho} \cdot \left(\frac{\alpha_e}{3} + 2\, \alpha_w (1 + ln(\delta)) \right)$
e neutrino	0	0	0	0	-1/2	-1/2	$m_{\nu_e} = -\frac{2\hbar}{c\rho} \cdot \alpha_w\, ln(\delta)$
up quark red	1	-1	0	2	-1/2	-1/2	$m_u = \frac{\hbar}{c\rho} [2\alpha_s + \frac{2}{9}\alpha_e + \alpha_w \cdot (1 - ln(\delta))]$
up quark green	0	1	-1	2	-1/2	-1/2	
up quark blue	-1	0	1	2	-1/2	-1/2	
down quark red	1	-1	0	-1	1	1	$m_d = \frac{\hbar}{c\rho} [2\alpha_s + \frac{1}{9}\alpha_e + 2\, \alpha_w \cdot (1 + \ln(\delta))]$
down quark green	0	1	-1	-1	1	1	
down quark blue	-1	0	1	-1	1	1	

For the higher generation particles, the excitation settings are identical to the one from the first generation. The difference comes solely with the additional mass constants. The respective anti-particles get all of the excitation numbers multiplied by -1. The Standard Model gauge bosons' excitation numbers can be deduced from known decay processes. In the process of electron-positron annihilation [38] two photons are produced (Figure 1).

$$e^+ + e^- \rightarrow 2\,\gamma$$

$$\begin{pmatrix} 0 \\ 0 \\ 0 \\ 3 \\ -1 \\ -1 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ -3 \\ 1 \\ 1 \end{pmatrix} \rightarrow \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ -1 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -1 \\ 1 \end{pmatrix}$$

Figure 1: Electron-positron annihilation into two photons

Two real measurable particles are created. The photons, as can be seen using equation (53), are massless. However, how can the other gauge bosons be accounted for? Do they exist as autonomous particles similar to the photon? The η_b meson has one decay mode evolving into a three-gluon event (Figure 2).

$$b\bar{b} \rightarrow 3\ g$$

$$\begin{pmatrix}1\\-1\\0\\-1\\1\\1\end{pmatrix}\begin{pmatrix}-1\\1\\0\\1\\-1\\-1\end{pmatrix} \rightarrow \begin{pmatrix}1\\-2\\1\\0\\0\\0\end{pmatrix} + \begin{pmatrix}1\\1\\-2\\0\\0\\0\end{pmatrix} + \begin{pmatrix}-2\\1\\1\\0\\0\\0\end{pmatrix}$$

Figure 2: η_b decay into three gluons

A direct measurement is, however, not possible. The questions that arise: Is the gluon a specific configuration in 10D-space in the decay process of the original particles and the decay product? Or does a real intermediate state, a gluon, exist independently in the process? The same questions can be directed at the other gauge bosons. In the neutron decay into a proton, an electron, and an anti-electron neutrino, a W^- has been declared as an intermediate state (Figure 3).

$$W^- \rightarrow e^- + \bar{\nu}_e$$

$$\begin{pmatrix}0\\0\\0\\-3\\3/2\\3/2\end{pmatrix} \rightarrow \begin{pmatrix}0\\0\\0\\-3\\1\\1\end{pmatrix} + \begin{pmatrix}0\\0\\0\\0\\1/2\\1/2\end{pmatrix}$$

Figure 3: A W^- boson decays into an electron and an anti-electron neutrino

It is important to note that: 1/2 must be deciphered as a superposition with excitation numbers one and zero. 3/2 stands for a superposition of 1 and 2. The last intermediate boson is the Z, which can decay via various channels e.g., into an electron-positron pair.

$$Z \rightarrow e^- + e^+$$

$$\begin{pmatrix}0\\0\\0\\0\\SP(1/-1)\\SP(1/-1)\end{pmatrix} \rightarrow \begin{pmatrix}0\\0\\0\\-1\\1\\1\end{pmatrix} + \begin{pmatrix}0\\0\\0\\1\\-1\\-1\end{pmatrix}$$

Figure 4: Z decay into a electron-positron pair. $SP(1/-1)$ stands for a superposition of the states 1 and -1.

The photon and the other intermediate bosons are presented in **Table 4**.

Table 4: Intermediate bosons

Particle	r_4 strong	r_5 strong	r_6 strong	r_7 electric	r_8 weak	r_9 weak	Mass formula
Photon γ	0	0	0	0	1	-1	$m_\gamma = \frac{2\,\alpha_w \hbar}{c\rho} \cdot [1-1] \cdot ln(\delta)$ massless from (53)
8 Gluons as superposition constructed out of quantities as this color red to green changing example $g_{r\bar{g}}$	1	-2	1	0	0	0	$m_{Gluon} = \frac{4\,\alpha_s \hbar}{c\rho} \cong 7.44 \cdot 10^{-28} kg \cong 417\ \frac{MeV}{c^2}$ If gluons are real intermediate particles massive
W^+	0	0	0	3	-3/2	-3/2	massive
W^-	0	0	0	-3	3/2	3/2	massive
Z	0	0	0	0	SP 1/-1	SP 1/-1	massive

Masses are created as excitations of the compactified dimensions; therefore, a Higgs-like boson is not a necessity within this development. An excitation always travels with the speed of light, while manifesting as a mass in ordinary space-time when induced through the higher dimensions.

Hadron masses

The magnetic multipliers as well as the coupling constants are not dependent on particle generation. That allows to calculate the hadron masses. First the meson masses – pseudoscalar and vector - and afterwards the baryon masses – spin $3\hbar/2$ and $\hbar/2$ - are calculated. The search for lists of particles ended by using those of Wikipedia [39, 40]. For each table a hypothetical combination with a top quark is added to demonstrate the expected masses. The measured particle masses shown are used in the comparison to the calculated values and to estimate the relative error. All other calculations, however, rest on data of the latest PDG publications [29]. All lists include the particle name, the symbol, quark content, measured and calculated masses in MeV/c^2 and kg, together with the standard deviations, the relative error, and the mass formula. The measured masses in kg are not stated with standard deviation, since these numbers are no longer used.

Meson masses

The spin of pseudo scalar mesons is anti-parallel, hence resulting in a net spin of $S = 0$ (**Table 5**).

Table 5: Masses of pseudo scalar mesons

Name	Symbol	Quark content	Measured mass		Calculated mass		Relative error	Mass formula
			MeV/c²	kg	kg	MeV/c²	$\frac{m_{meas} - m_{calc}}{m_{meas}}$	
Pion⁺	π^+	$u\bar{d}$	$139.57018(35)$	$2.488073 \cdot 10^{-28}$	Used to calculate α_s, M, N	exact	0	$m_{\pi^+} = m_u + m_{\bar{d}} + N - \frac{2\,M}{m_u} - \frac{2\,M}{m_{\bar{d}}}$
Pion⁰	π^0	$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$	$134.9766(6)$	$2.406183 \cdot 10^{-28}$	Used to calculate α_s, M, N	exact	0	$m_{\pi^0} = \frac{m_d + m_{\bar{d}} + m_u + m_{\bar{u}}}{2} + \frac{1}{2} \cdot \left(20\,N - \frac{M}{m_d} - \frac{M}{m_{\bar{d}}} - \frac{4\,M}{m_u} - \frac{4\,M}{m_{\bar{u}}}\right)$
Kaon +	K^+	$u\bar{s}$	$493.677(16)$	$8.8006 \cdot 10^{-28}$	$8.7301(50) \cdot 10^{-28}$	489.72(28)	0.008	$m_{u\bar{s}} = m_u + m_{\bar{s}} + N - \frac{2\,M}{m_u} - \frac{2\,M}{m_{\bar{s}}}$
Kaon 0	K^0	$d\bar{s}$	$497.614(24)$	$8.8708 \cdot 10^{-28}$	$1.09528(56) \cdot 10^{-27}$	614.41(31)	-0.235	$m_{d\bar{s}} = m_d + m_{\bar{s}} + 4\,N - \frac{M}{m_d} - \frac{M}{m_{\bar{s}}}$
D +	D^+	$c\bar{d}$	$1869.61(10)$	$3.3329 \cdot 10^{-27}$	$2.78524(50) \cdot 10^{-27}$	1562.40(28)	0.164	$m_{c\bar{d}} = m_c + m_{\bar{d}} + N - \frac{2\,M}{m_c} - \frac{2\,M}{m_{\bar{d}}}$
D 0	D^0	$c\bar{u}$	$1864.84(7)$	$3.3245 \cdot 10^{-27}$	$2.6942(18) \cdot 10^{-27}$	1511.3(1.0)	0.190	$m_{c\bar{u}} = m_c + m_{\bar{u}} + 16\,N - \frac{4\,M}{m_c} - \frac{4\,M}{m_{\bar{u}}}$
Strange D	D_s^+	$c\bar{s}$	$1968.30(11)$	$3.5088 \cdot 10^{-27}$	$3.40944(10) \cdot 10^{-27}$	1912.555(56)	0.028	$m_{c\bar{s}} = m_c + m_{\bar{s}} + N - \frac{2\,M}{m_c} - \frac{2\,M}{m_{\bar{s}}}$
Charm eta	η_c	$c\bar{c}$	$2983.6(7)$	$5.3187 \cdot 10^{-27}$	$5.4500(16) \cdot 10^{-27}$	3057.23(90)	-0.025	$m_{c\bar{c}} = m_c + m_{\bar{c}} + 16\,N - \frac{4\,M}{m_c} - \frac{4\,M}{m_{\bar{c}}}$
B +	B^+	$u\bar{b}$	$5279.26(17)$	$9.4111 \cdot 10^{-27}$	$9.04937(57) \cdot 10^{-27}$	5076.32(32)	0.038	$m_{u\bar{b}} = m_u + m_{\bar{b}} + N - \frac{2\,M}{m_u} - \frac{2\,M}{m_{\bar{b}}}$
B 0	B^0	$d\bar{b}$	$5279.58(17)$	$9.4117 \cdot 10^{-27}$	$9.22131(63) \cdot 10^{-27}$	5172.78(35)	0.020	$m_{d\bar{b}} = m_d + m_{\bar{b}} + 4\,N - \frac{M}{m_d} - \frac{M}{m_{\bar{b}}}$
Strange B	B_s^0	$s\bar{b}$	$5366.77(24)$	$9.5671 \cdot 10^{-27}$	$9.77371(49) \cdot 10^{-27}$	5482.65(27)	-0.022	$m_{s\bar{b}} = m_s + m_{\bar{b}} + 4\,N - \frac{M}{m_s} - \frac{M}{m_{\bar{b}}}$
Charm B	B_c^+	$c\bar{b}$	$6275.6(1.1)$	$1.1187 \cdot 10^{-26}$	$1.158580(29) \cdot 10^{-26}$	6499.16(16)	-0.036	$m_{c\bar{b}} = m_c + m_{\bar{b}} + N - \frac{2\,M}{m_c} - \frac{2\,M}{m_{\bar{b}}}$
Bottom eta	η_b	$b\bar{b}$	$9398.0(3.2)$	$1.6753 \cdot 10^{-26}$	$1.789973(56) \cdot 10^{-26}$	10041.01(31)	-0.068	$m_{b\bar{b}} = m_b + m_{\bar{b}} + 4\,N - \frac{M}{m_b} - \frac{M}{m_{\bar{b}}}$
		$t\bar{d}$	---	---	$3.0810(53) \cdot 10^{-25}$	172831.(297.)	---	$m_{t\bar{d}} = m_t + m_{\bar{d}} + N - \frac{2\,M}{m_t} - \frac{2\,M}{m_{\bar{d}}}$

The vector mesons have a net spin of $S = \hbar$. The quark and the anti-quark spins point in the same direction (**Table 6**).

Table 6: Masses of vector mesons

Name	Symbol	Quark content	Measured mass		Calculated mass		Relative error	Mass formula
			MeV/c²	kg	kg	MeV/c²	$\frac{m_{meas}-m_{calc}}{m_{meas}}$	
Charged rho	ρ^+	$u\bar{d}$	$775.11(34)$	$1.3823 \cdot 10^{-27}$	$1.37384(93) \cdot 10^{-27}$	770.67(52)	0.006	$m_{\rho^+} = m_u + m_{\bar{d}} + 9N + \frac{2\,M}{m_u} + \frac{2\,M}{m_{\bar{d}}}$
Neutral rho	ρ^0	$\frac{1}{\sqrt{2}}(u\bar{u}-d\bar{d})$	$775.26(25)$	$1.3820 \cdot 10^{-27}$	Used to calculate α_s, M, N	exact	0	$m_{\rho^0} = \frac{m_d + m_{\bar{d}} + m_u + m_{\bar{u}}}{2} + \frac{1}{2} \cdot \left(\frac{M}{m_d} + \frac{M}{m_{\bar{d}}} + \frac{4\,M}{m_u} + \frac{4\,M}{m_{\bar{u}}}\right)$
Phi	ϕ	$s\bar{s}$	$1019.461(19)$	$1.81735 \cdot 10^{-27}$	Used to calculate m_s and A_s	exact	0	$m_{s\bar{s}} = m_s + m_{\bar{s}} + \frac{M}{m_s} + \frac{M}{m_{\bar{s}}}$
Kaon *+	K^{*+}	$u\bar{s}$	$891.66(26)$	$1.5895 \cdot 10^{-27}$	$1.71082(92) \cdot 10^{-27}$	959.70(52)	-0.076	$m_{u\bar{s}} = m_u + m_{\bar{s}} + 9N + \frac{2\,M}{m_u} + \frac{2\,M}{m_{\bar{s}}}$
Kaon 0	K^{*0}	$d\bar{s}$	$895.81(19)$	$1.5969 \cdot 10^{-27}$	$1.46148(45) \cdot 10^{-27}$	819.83(25)	0.085	$m_{d\bar{s}} = m_d + m_{\bar{s}} + \frac{M}{m_d} + \frac{M}{m_{\bar{s}}}$
D *+	D^{*+}	$c\bar{d}$	$2010.26(07)$	$3.5836 \cdot 10^{-27}$	$3.47147(92) \cdot 10^{-27}$	1952.26(31)	0.031	$m_{c\bar{d}} = m_c + m_{\bar{d}} + 9N + \frac{2\,M}{m_c} + \frac{2\,M}{m_{\bar{d}}}$
D *0	D^{*0}	$c\bar{u}$	$2006.96(10)$	$3.5777 \cdot 10^{-27}$	$3.64250(13) \cdot 10^{-27}$	2043.293(73)	-0.018	$m_{c\bar{u}} = m_c + m_{\bar{u}} + \frac{4\,M}{m_c} + \frac{4\,M}{m_{\bar{u}}}$
Strange D	D_s^{*+}	$c\bar{s}$	$2112.1(4)$	$3.7651 \cdot 10^{-27}$	$3.80845(38) \cdot 10^{-27}$	2136.38(21)	-0.011	$m_{c\bar{s}} = m_c + m_{\bar{s}} + 9N + \frac{2\,M}{m_c} + \frac{2\,M}{m_{\bar{s}}}$
J/Psi	J/ψ	$c\bar{c}$	$3096.916(11)$	$5.52075 \cdot 10^{-27}$	Used to calculate m_c and A_c	exact	0	$m_{c\bar{c}} = m_c + m_{\bar{c}} + \frac{4\,M}{m_c} + \frac{4\,M}{m_{\bar{c}}}$
B +	B^{*+}	$u\bar{b}$	$5325.2(4)$	$9.4930 \cdot 10^{-27}$	$9.68585(96) \cdot 10^{-27}$	5433.36(54)	-0.020	$m_{u\bar{b}} = m_u + m_{\bar{b}} + 9N + \frac{2\,M}{m_u} + \frac{2\,M}{m_{\bar{b}}}$
B *0	B^{*0}	$d\bar{b}$	$5325.2(4)$	$9.4930 \cdot 10^{-27}$	$9.43393(34) \cdot 10^{-27}$	5292.05(19)	0.006	$m_{d\bar{b}} = m_d + m_{\bar{b}} + \frac{M}{m_d} + \frac{M}{m_{\bar{b}}}$
Strange B	B_s^{*0}	$s\bar{b}$	$5415.40(24)$	$9.65380 \cdot 10^{-27}$	$9.84272(28) \cdot 10^{-27}$	5521.36(16)	-0.020	$m_{s\bar{b}} = m_s + m_{\bar{b}} + \frac{M}{m_s} + \frac{M}{m_{\bar{b}}}$
Charmed B	B_c^{*+}	$c\bar{b}$	unknown	---	$1.178348(96) \cdot 10^{-26}$	6610.05(54)	---	$m_{c\bar{b}} = m_c + m_{\bar{b}} + 9N + \frac{2\,M}{m_c} + \frac{2\,M}{m_{\bar{b}}}$
Upsilon	Υ	$b\bar{b}$	$9460.30(26)$	$1.68645 \cdot 10^{-26}$	Used to calculate m_b and A_b	exact	0	$m_{b\bar{b}} = m_b + m_{\bar{b}} + \frac{M}{m_b} + \frac{M}{m_{\bar{b}}}$
		$t\bar{d}$	unknown	---	$3.0872(53) \cdot 10^{-25}$	173179.(297.)	---	$m_{t\bar{d}} = m_t + m_{\bar{d}} + 9N + \frac{2\,M}{m_t} + \frac{2\,M}{m_{\bar{d}}}$

Baryon masses

Baryons consist of 3 quarks. They come as $3\hbar/2$ and $\hbar/2$ spin versions. As with the mesons, the calculations of the magnetic masses differ depending on the spin status. The general mass statement is identical for both versions, but the specific calculation of the various contributions differs. The baryon mass is

$$m_{q_o q_n q_p} = m_{q_o} + m_{q_n} + m_{q_p} + m^B_{q_o q_n q_p} + \left| m^{dipole}_{q_o} + m^{dipole}_{q_n} + m^{dipole}_{q_p} \right| \qquad (83)$$

The spin $3\hbar/2$ baryons' magnetic masses are

$$m^B_{q_o q_n q_p} = N \cdot \left| o_7 + n_7 + p_7 \right|^2 \qquad m^{dipole}_{q_o} = -\frac{M}{m_{q_o}} \cdot \left[o_7 \cdot (n_7 + p_7) \right] \qquad (84)$$

$$m^{dipole}_{q_n} = -\frac{M}{m_{q_n}} \cdot \left[n_7 \cdot (p_7 + o_7) \right] \qquad m^{dipole}_{q_p} = -\frac{M}{m_{q_p}} \cdot \left[p_7 \cdot (o_7 + n_7) \right]$$

Each quark combines with their two neighboring quarks, therefore, the order of the quarks is of no concern (**Table 7**).

Table 7: Masses of Baryons with spin $3\hbar/2$

Name	Symbol	Quark content	Measured mass		Calculated mass		Relative error	Mass formula
			MeV/c²	kg	kg	MeV/c²	$\frac{m_{meas}-m_{calc}}{m_{meas}}$	
Delta	Δ^{++}	uuu	$1232(2)$	$2.1963 \cdot 10^{-27}$	$4.6508(40) \cdot 10^{-27}$	2608.9(2.2)	-1.118	$m_{\Delta^{++}} = 3\,m_u + 36\,N + \frac{24\,M}{m_u}$
Delta	Δ^{+}	uud	$1232(2)$	$2.1963 \cdot 10^{-27}$	$2.25618(95) \cdot 10^{-27}$	1265.62(53)	-0.027	$m_{\Delta^{+}} = 2\,m_u + m_d + 9\,N + \frac{4\,M}{m_u} + \frac{4\,M}{m_d}$
Delta	Δ^{0}	udd	$1232(2)$	$2.1963 \cdot 10^{-27}$	$1.88192(40) \cdot 10^{-27}$	1055.68(22)	0.143	$m_{\Delta^{0}} = m_u + 2m_d + \frac{4\,M}{m_u} + \frac{2\,M}{m_d}$
Delta	Δ^{-}	ddd	$1232(2)$	$2.1963 \cdot 10^{-27}$	$2.00108(96) \cdot 10^{-27}$	1122.52(54)	0.089	$m_{\Delta^{-}} = 3\,m_d + 9\,N + \frac{6\,M}{m_d}$
Sigma plus	Σ^{*+}	uus	$1382.80(35)$	$2.4651 \cdot 10^{-27}$	$2.44955(94) \cdot 10^{-27}$	1374.10(53)	0.006	$m_{\Sigma^{*+}} = 2\,m_u + m_s + 9\,N + \frac{4\,M}{m_u} + \frac{4\,M}{m_s}$
Sigma	Σ^{*0}	uds	$1383.7(1.0)$	$2.4667 \cdot 10^{-27}$	$2.29070(23) \cdot 10^{-27}$	1284.99(13)	0.071	$m_{\Sigma^{*0}} = m_u + m_d + m_s + \frac{4\,M}{m_u} + \frac{M}{m_d} + \frac{M}{m_s}$
Sigma minus	Σ^{*-}	dds	$1387.2(5)$	$2.4729 \cdot 10^{-27}$	$2.33807(94) \cdot 10^{-27}$	1311.56(53)	0.055	$m_{\Sigma^{*-}} = 2m_d + m_s + 9\,N + \frac{4\,M}{m_d} + \frac{2\,M}{m_s}$
Charmed Sigma double plus	Σ_c^{++}	uuc	$2518.41(21)$	$4.4895 \cdot 10^{-27}$	$6.0902(38) \cdot 10^{-27}$	3416.4(2.1)	-0.357	$m_{\Sigma_c^{++}} = 2\,m_u + m_c + 36\,N + \frac{16\,M}{m_u} + \frac{8\,M}{m_c}$
Charmed Sigma plus	Σ_c^{*+}	udc	$2517.5(2.3)$	$4.4879 \cdot 10^{-27}$	$4.35381(93) \cdot 10^{-27}$	2442.31(52)	0.030	$m_{\Sigma_c^{*+}} = m_d + m_u + m_c + 9\,N + \frac{4\,M}{m_d} + \frac{2\,M}{m_u} + \frac{2\,M}{m_c}$
Charmed Sigma	Σ_c^{*0}	ddc	$2518.48(20)$	$4.4896 \cdot 10^{-27}$	$3.76014(38) \cdot 10^{-27}$	2109.28(21)	0.162	$m_{\Sigma_c^{*0}} = 2\,m_d + m_c + \frac{2\,M}{m_d} + \frac{4\,M}{m_c}$
Bottom Sigma	Σ_b^{*+}	uub	$5830.32(27)$	$1.0393 \cdot 10^{-26}$	$1.032392(98) \cdot 10^{-26}$	5791.29(55)	0.007	$m_{\Sigma_b^{*+}} = 2\,m_u + m_b + 9\,N + \frac{4\,M}{m_u} + \frac{4\,M}{m_b}$
Bottom Sigma	Σ_b^{*0}	udb	unknown	---	$1.03161(40) \cdot 10^{-26}$	5786.9(2.2)	---	$m_{\Sigma_b^{*0}} = m_u + m_d + m_b + \frac{4\,M}{m_u} + \frac{M}{m_d} + \frac{M}{m_b}$
Bottom Sigma	Σ_b^{*-}	ddb	$5834.742(30$	$1.0393 \cdot 10^{-26}$	$1.03131(97) \cdot 10^{-26}$	5785.2(5.4)	0.008	$m_{\Sigma_b^{*-}} = 2\,m_d + m_b + 9\,N + \frac{4\,M}{m_d} + \frac{2\,M}{m_b}$
Xi	Ξ^{*0}	uss	$1531.80(32)$	$2.7307 \cdot 10^{-27}$	$2.69949(13) \cdot 10^{-27}$	1514.303(73)	0.011	$m_{\Xi^{*0}} = m_u + 2\,m_s + \frac{4\,M}{m_u} + \frac{2\,M}{m_s}$
Xi	Ξ^{*-}	dss	$1535.0(6)$	$2.7364 \cdot 10^{-27}$	$2.67505(92) \cdot 10^{-27}$	1500.59(52)	0.022	$m_{\Xi^{*-}} = m_d + 2\,m_s + 9\,N + \frac{2\,M}{m_d} + \frac{4\,M}{m_s}$
Charmed Xi	Ξ_c^{*+}	usc	$2645.56(30)$	$4.7161 \cdot 10^{-27}$	$4.54718(92) \cdot 10^{-27}$	2550.78(52)	0.036	$m_{\Xi_c^{*+}} = m_u + m_c + m_s + 9\,N + \frac{2\,M}{m_u} + \frac{2\,M}{m_c} + \frac{4\,M}{m_s}$
Charmed Xi	Ξ_c^{*0}	dsc	$2646.38(23)$	$4.7176 \cdot 10^{-27}$	$4.16893(19) \cdot 10^{-27}$	2338.60(11)	0.116	$m_{\Xi_c^{*0}} = m_d + m_s + m_c + \frac{M}{m_d} + \frac{M}{m_s} + \frac{4\,M}{m_c}$
Double charmed Xi	Ξ_{cc}^{*++}	ucc	unknown	---	$7.5297(37) \cdot 10^{-27}$	4223.9(2.1)	---	$m_{\Xi_{cc}^{*++}} = m_u + 2\,m_c + 36\,N + \frac{8\,M}{m_u} + \frac{16\,M}{m_c}$

Double charmed Xi	Ξ_{cc}^{*+}	dcc	unknown	---	$6.45144(92) \cdot 10^{-27}$	3618.99(52)	---	$m_{\Xi_{cc}^{*+}} = m_d + 2\,m_c + 9\,N + \frac{4\,M}{m_d} + \frac{4\,M}{m_c}$
Bottom Xi	Ξ_b^{*0}	usb	5952.3(6)	$1.0611 \cdot 10^{-26}$	$1.072486(30) \cdot 10^{-26}$	6016.20(17)	-0.011	$m_{\Xi_b^{*0}} = m_u + m_s + m_b + \frac{4\,M}{m_u} + \frac{M}{m_s} + \frac{M}{m_b}$
Bottom Xi	Ξ_b^{*0}	dsb	5955.33(17)	$1.0616 \cdot 10^{-26}$	$1.065008(96) \cdot 10^{-26}$	5974.26 (54)	-0.003	$m_{\Xi_b^{*0}} = m_d + m_s + m_b + 9\,N + \frac{2\,M}{m_d} + \frac{2\,M}{m_s} + \frac{2\,M}{m_b}$
Double bottom Xi	Ξ_{bb}^{*0}	ubb	unknown	---	$1.875022(57) \cdot 10^{-26}$	10518.10(32)	---	$m_{\Xi_{bb}^{*0}} = m_u + 2m_b + \frac{4\,M}{m_u} + \frac{2\,M}{m_b}$
Double bottom Xi	Ξ_{bb}^{*-}	dbb	unknown	---	$1.86251(11) \cdot 10^{-26}$	10447.91(62)	---	$m_{\Xi_{bb}^{*-}} = m_d + 2\,m_b + 9\,N + \frac{2\,M}{m_d} + \frac{4\,M}{m_b}$
Charmed bottom Xi	Ξ_{cb}^{*+}	ucb	unknown	---	$1.242155(96) \cdot 10^{-26}$	6967.98(54)	---	$m_{\Xi_{cb}^{*+}} = m_b + m_u + m_c + 9\,N + \frac{4\,M}{m_b} + \frac{2\,M}{m_u} + \frac{2\,M}{m_c}$
Charmed bottom Xi	Ξ_{cb}^{*0}	dcb	unknown	---	$1.219430(37) \cdot 10^{-26}$	6840.50(21)	---	$m_{\Xi_{cb}^{*0}} = m_d + m_b + m_c + \frac{M}{m_d} + \frac{M}{m_b} + \frac{4\,M}{m_c}$
Omega	Ω^-	sss	1672.45(29)	$2.9814 \cdot 10^{-27}$	$3.01203(92) \cdot 10^{-27}$	1689.62(52)	-0.010	$m_{\Omega^-} = 3\,m_s + 9\,N + \frac{6\,M}{m_s}$
Charmed Omega	Ω_c^{*0}	ssc	2765.9(2.0)	$4.9307 \cdot 10^{-27}$	$4.577717(38) \cdot 10^{-27}$	2567.911(21)	0.072	$m_{\Omega_c^{*0}} = 2\,m_s + m_c + \frac{2\,M}{m_s} + \frac{4\,M}{m_c}$
Bottom Omega	Ω_b^{*-}	ssb	unknown	---	$1.098706(96) \cdot 10^{-26}$	6163.29(54)	---	$m_{\Omega_b^{*-}} = 2\,m_s + m_b + 9\,N + \frac{4\,M}{m_s} + \frac{2\,M}{m_b}$
Double charmed Omega	Ω_{cc}^{*+}	scc	unknown	---	$6.64481(92) \cdot 10^{-27}$	3727.46(52)	---	$m_{\Omega_{cc}^{*+}} = m_s + 2\,m_c + 9\,N + \frac{4\,M}{m_s} + \frac{4\,M}{m_c}$
Charmed bottom Omega	Ω_{cb}^{*0}	scb	unknown	---	$1.260308(28) \cdot 10^{-26}$	7069.81(16)	---	$m_{\Omega_{cb}^{*0}} = m_c + m_s + m_b + \frac{4\,M}{m_c} + \frac{M}{m_s} + \frac{M}{m_b}$
Double bottom Omega	Ω_{bb}^{*-}	sbb	unknown	---	$1.89621(11) \cdot 10^{-26}$	10079.54(31)	---	$m_{\Omega_{bb}^{*-}} = m_s + 2\,m_b + 9\,N + \frac{2\,M}{m_s} + \frac{4\,M}{m_b}$
Triple charmed Omega	Ω_{ccc}^{++}	ccc	unknown	---	$8.9691(37) \cdot 10^{-27}$	5031.3(2.1)	---	$m_{\Omega_{ccc}^{++}} = 3\,m_c + 36\,N + \frac{24\,M}{m_c}$
Double charmed bottom Omega	Ω_{ccb}^{*+}	ccb	unknown	---	$1.451918(96) \cdot 10^{-26}$	8144.66(54)	---	$m_{\Omega_{ccb}^{*+}} = 2\,m_c + m_b + 9\,N + \frac{4\,M}{m_c} + \frac{4\,M}{m_b}$
Charmed double bottom Omega	Ω_{cbb}^{*0}	cbb	unknown	---	$2.062845(55) \cdot 10^{-26}$	11571.71(31)	---	$m_{\Omega_{cbb}^{*0}} = 2\,m_b + m_c + \frac{2\,M}{m_b} + \frac{4\,M}{m_c}$
Triple bottom Omega	Ω_{bbb}^{-}	bbb	unknown	---	$2.69371(12) \cdot 10^{-26}$	15110.60(67)	---	$m_{\Omega_{bbb}^{-}} = 3\,m_b + 9\,N + \frac{6\,M}{m_b}$
		tdd	unknown	---	$3.0897(53) \cdot 10^{-25}$	173319.(297.)	---	$m_{tdd} = m_t + 2m_d + \frac{4\,M}{m_t} + \frac{2\,M}{m_d}$

For the spin $\hbar/2$ baryons, the situation is different. Here, one of the quarks performed a spinflip, therefore breaking the symmetry. Consequently, different configurations result in different masses, while the quark content remains the same. An example is the different masses of the Λ^0 and the Σ^0 baryons, both of which consist of one d, one u and one s quark. This symmetry breaking – q_p is flipped - then causes changes with the calculation of the magnetic masses to

$$m^{B}_{q_o q_n q_p} = N \cdot \left|(o_7 + n_7)^2 - p_7^2\right| \tag{85}$$

$$m_{q_o}^{dipole} = -\frac{M}{m_{q_o}} \cdot [o_7 \cdot n_7] \qquad m_{q_n}^{dipole} = -\frac{M}{m_{q_n}} \cdot [n_7 \cdot (-p_7)] \qquad m_{q_p}^{dipole} = -\frac{M}{m_{q_p}} \cdot [(-p_7) \cdot o_7]$$

If two or three of the same species of quarks contribute to their “dipole masses”, these must first be added . Afterwards, the absolute of the values is summed up and contributing to the mass caused by magnetism. All of the various quark orders must be taken into consideration. In principle, there is a maximum of 6 combinations with 6 different masses possible: three even and three odd permutations (**Table 8**).

Table 8: Masses of Baryons with spin $\hbar/2$

Name	Symbol	Quark content	Measured mass		Calculated mass		Relative error	Mass formula
			MeV/c²	kg	kg	MeV/c²	$\frac{m_{meas}-m_{calc}}{m_{meas}}$	
Proton	P^+	duu udu uud	938.2720813(58)	$1.672621637\cdot10^{-27}$	$1.66721(50)\cdot10^{-27}$ $2.17660(34)\cdot10^{-27}$ $2.3353(15)\cdot10^{-27}$	935.24(28) 1220.98(19) 1310.01(84)	0.003 -0.301 -0.396	$m_{P^+}(1)=m_d+2\,m_u+3\,N+\frac{2\,M}{m_d}+\frac{2\,M}{m_u}$ $m_{P^+}(2)=m_d+2\,m_u+3\,N+\frac{2\,M}{m_d}+\frac{6\,M}{m_u}$ $m_{P^+}(3)=m_d+2\,m_u+15\,N+\frac{2\,M}{m_d}+\frac{6\,M}{m_u}$
Neutron	N^0	udd ddu, dud	939.5654133(58)	$1.674927558\cdot10^{-27}$	$1.49977(49)\cdot10^{-27}$ $1.75467(31)\cdot10^{-27}$	841.31(27) 984.30(17)	0.105 -0.048	$m_{N^0}(1)=2\,m_d+m_u+\frac{M}{m_d}+\frac{2\,M}{m_u}$ $m_{N^0}(2)=2\,m_d+m_u+\frac{3\,M}{m_d}+\frac{2\,M}{m_u}$
Lambda	Λ^0	dsu, uds, sud	1115.683(6)	$1.988886\cdot10^{-27}$	$2.09165(22)\cdot10^{-27}$	1173.33(12)	-0.052	$m_{\Lambda^0}=m_u+m_d+m_s+\frac{2\,M}{m_u}+\frac{M}{m_d}+\frac{2\,M}{m_s}$
Charmed Lambda	Λ_c^+	dcu, udc cud	2286.46(14)	$4.0759850\cdot10^{-27}$	$4.05483(34)\cdot10^{-27}$ $4.2136(15)\cdot10^{-27}$	2274.59(19) 2363.66(84)	0.005 -0.034	$m_{\Lambda^0}(1)=m_u+m_d+m_c+3\,N+\frac{2\,M}{m_u}+\frac{2\,M}{m_d}+\frac{4\,M}{m_c}$ $m_{\Lambda^0}(2)=m_u+m_d+m_c+15\,N+\frac{2\,M}{m_u}+\frac{2\,M}{m_d}+\frac{4\,M}{m_c}$
Bottom Lambda	Λ_b^0	dbu, udb, bud	5619.60(14)	$1.00178\cdot10^{-26}$	$1.00667(35)\cdot10^{-26}$	5647.0(2.0)	-0.005	$m_{\Lambda_b^0}=m_u+m_d+m_b+\frac{2\,M}{m_u}+\frac{M}{m_d}+\frac{2\,M}{m_b}$
Sigma plus	Σ^+	suu usu uus	1189.37(07)	$2.12024\cdot10^{-27}$	$2.00419(49)\cdot10^{-27}$ $2.51358(32)\cdot10^{-27}$ $2.6723(15)\cdot10^{-27}$	1124.27(27) 1410.01(18) 1499.05(84)	0.055 -0.186 -0.260	$m_{\Sigma^+}(1)=2\,m_u+m_s+3\,N+\frac{2\,M}{m_u}+\frac{2\,M}{m_s}$ $m_{\Sigma^+}(2)=2\,m_u+m_s+3\,N+\frac{6\,M}{m_u}+\frac{2\,M}{m_s}$ $m_{\Sigma^+}(3)=2\,m_u+m_s+15\,N+\frac{6\,M}{m_u}+\frac{2\,M}{m_s}$
Sigma zero	Σ^0	sdu, usd, dus	1192.642(24)	$2.12607\cdot10^{-27}$	$2.16346(15)\cdot10^{-27}$	1213.612(84)	-0.018	$m_{\Sigma^0}=m_u+m_d+m_s+\frac{2\,M}{m_u}+\frac{2\,M}{m_d}+\frac{M}{m_s}$
Sigma minus	Σ^-	dsd, dds sdd	1197.449(30)	$2.134647\cdot10^{-27}$	$1.69324(65)\cdot10^{-27}$ $1.94814(49)\cdot10^{-27}$	949.84(36) 1092.83(27)	0.207 0.087	$m_{\Sigma^-}(1)=2\,m_d+m_s+3\,N+\frac{M}{m_s}$ $m_{\Sigma^-}(2)=2\,m_d+m_s+3\,N+\frac{2\,M}{m_d}+\frac{M}{m_s}$
Charmed Sigma	Σ_c^{++}	ucu, uuc cuu	2453.97(14)	$4.37460\cdot10^{-27}$	$3.6646(13)\cdot10^{-27}$ $4.6834(12)\cdot10^{-27}$	2055.69(73) 2627.19(67)	0.162 -0.071	$m_{\Sigma_c^{++}}(1)=m_c+2\,m_u+12\,N+\frac{4\,M}{m_c}$ $m_{\Sigma_c^{++}}(2)=m_c+2\,m_u+12\,N+\frac{4\,M}{m_c}+\frac{8\,M}{m_u}$
Charmed Sigma	Σ_c^+	cdu, duc ucd	2452.9(4)	$4.3727\cdot10^{-27}$	$4.27423(35)\cdot10^{-27}$ $4.4330(15)\cdot10^{-27}$	2397.67(20) 2486.73(84)	0.023 -0.014	$m_{\Sigma_c^+}(1)=m_c+m_u+m_d+3\,N+\frac{2\,M}{m_c}+\frac{4\,M}{m_u}+\frac{2\,M}{m_d}$ $m_{\Sigma_c^+}(2)=m_c+m_u+m_d+15\,N+\frac{2\,M}{m_c}+\frac{4\,M}{m_u}+\frac{2\,M}{m_d}$

Charmed Sigma	Σ_c^0	cdd ddc, dcd	2453.75(14)	$4.37421 \cdot 10^{-27}$	$3.59740(48) \cdot 10^{-27}$ $3.85230(29) \cdot 10^{-27}$	2017.99(27) 2160.98(16)	0.178 0.119	$m_{\Sigma_c^0}(1) = 2\,m_d + m_c + \frac{M}{m_d} + \frac{2\,M}{m_c}$ $m_{\Sigma_c^0}(2) = 2\,m_d + m_c + \frac{3\,M}{m_d} + \frac{2\,M}{m_c}$
Bottom Sigma	Σ_b^+	buu ubu uub	5810.56(25)	$1.03583 \cdot 10^{-26}$	$9.97922(56) \cdot 10^{-27}$ $1.04886(42) \cdot 10^{-26}$ $1.06474(16) \cdot 10^{-26}$	5597.93(31) 5883.7(2.4) 5972.75(90)	0.037 -0.013 -0.028	$m_{\Sigma_b^+}(1) = 2\,m_u + m_b + 3\,N + \frac{2\,M}{m_u} + \frac{2\,M}{m_b}$ $m_{\Sigma_b^+}(2) = 2\,m_u + m_b + 3\,N + \frac{6\,M}{m_u} + \frac{2\,M}{m_b}$ $m_{\Sigma_b^+}(2) = 2\,m_u + m_b + 15\,N + \frac{6\,M}{m_u} + \frac{2\,M}{m_b}$
Bottom Sigma	Σ_b^0	bdu, ubd, du	unknown	---	$1.018882(31) \cdot 10^{-26}$	5715.51(17)	---	$m_{\Sigma_b^0} = m_u + m_d + m_b + \frac{2\,M}{m_u} + \frac{2\,M}{m_d} + \frac{M}{m_b}$
Bottom Sigma	Σ_b^-	ddb, dbd bdd	5815.64(27)	$1.03673 \cdot 10^{-26}$	$9.71860(71) \cdot 10^{-27}$ $9.97351(56) \cdot 10^{-27}$	5451.73(40) 5594.73(31)	0.063 0.038	$m_{\Sigma_b^-}(1) = 2\,m_d + m_b + 3\,N + \frac{M}{m_b}$ $m_{\Sigma_b^-}(2) = 2\,m_d + m_b + 3\,N + \frac{2\,M}{m_d} + \frac{M}{m_b}$
Xi	Ξ^0	uss sus, ssu	1314.86(20)	$2.34395 \cdot 10^{-27}$	$2.38915(10) \cdot 10^{-27}$ $2.50044(12) \cdot 10^{-27}$	1340.215(56) 1402.644(67)	-0.019 -0.067	$m_{\Xi^0}(1) = m_u + 2\,m_s + \frac{2\,M}{m_u} + \frac{M}{m_s}$ $m_{\Xi^0}(2) = m_u + 2\,m_s + \frac{2\,M}{m_u} + \frac{3\,M}{m_s}$
Xi	Ξ^-	ssd, sds dss	1321.71(7)	$2.35616 \cdot 10^{-27}$	$2.24564(36) \cdot 10^{-27}$ $2.35693(36) \cdot 10^{-27}$	1259.69(20) 1322.14(20)	0.047 -0.0003	$m_{\Xi^-}(1) = 2\,m_s + m_d + 3\,N + \frac{M}{m_d}$ $m_{\Xi^-}(2) = 2\,m_s + m_d + 3\,N + \frac{2\,M}{m_s} + \frac{M}{m_d}$
Charmed Xi	Ξ_c^+	usc, cus, scu	2467.94(20)	$4.39950 \cdot 10^{-27}$	$4.39181(32) \cdot 10^{-27}$	2463.62(18)	0.002	$m_{\Xi_c^+} = m_u + m_s + m_c + 3\,N + \frac{2\,M}{m_u} + \frac{2\,M}{m_s} + \frac{4\,M}{m_c}$
Charmed Xi	Ξ_c^0	dsc, cds, scd	2470.90(29)	$4.40478 \cdot 10^{-27}$	$4.18928(19) \cdot 10^{-27}$	2350.01(11)	0.049	$m_{\Xi_c^0} = m_d + m_s + m_c + \frac{M}{m_d} + \frac{2\,M}{m_s} + \frac{2\,M}{m_c}$
Charmed Xi prime	$\Xi_c^{\prime +}$	ucs, suc, csu	2578.4(5)	$4.59642 \cdot 10^{-27}$	$4.61121(33) \cdot 10^{-27}$	2586.70(19)	-0.003	$m_{\Xi_c^{\prime +}} = m_u + m_s + m_c + 3\,N + \frac{4\,M}{m_u} + \frac{2\,M}{m_c} + \frac{2\,M}{m_s}$
Charmed Xi prime	$\Xi_c^{\prime 0}$	dcs, sdc, dcs	2579.2(5)	$4.59784 \cdot 10^{-27}$	$4.26109(10) \cdot 10^{-27}$	2390.296(56)	0.073	$m_{\Xi_c^{\prime 0}} = m_d + m_s + m_c + \frac{2\,M}{m_d} + \frac{M}{m_s} + \frac{2\,M}{m_c}$
Double charmed Xi	Ξ_{cc}^{++}	cuc, ccu ucc	3621.2(7)	$6.4554 \cdot 10^{-27}$	$6.42042(12) \cdot 10^{-27}$ $6.56160(12) \cdot 10^{-27}$	3601.591(67) 3680.787(67)	0.005 -0.016	$m_{\Xi_{cc}^{++}}(1) = m_u + 2\,m_c + 12\,N + \frac{4\,M}{m_u}$ $m_{\Xi_{cc}^{++}}(2) = m_u + 2\,m_c + 12\,N + \frac{4\,M}{m_u} + \frac{8\,M}{m_c}$
Double charmed Xi	Ξ_{cc}^+	dcc cdc, ccd	unknown	--- ---	$6.08187(32) \cdot 10^{-27}$ $6.15246(32) \cdot 10^{-27}$	3411.68(18) 3451.28(18)	--- ---	$m_{\Xi_{cc}^+}(1) = m_d + 2\,m_c + 3\,N + \frac{2\,M}{m_d} + \frac{2\,M}{m_c}$ $m_{\Xi_{cc}^+}(2) = m_d + 2\,m_c + 3\,N + \frac{2\,M}{m_d} + \frac{6\,M}{m_c}$
Bottom Xi	Ξ_b^0	usb, bus, sbu	5791.9(5)	$1.0325 \cdot 10^{-26}$	$1.047547(29) \cdot 10^{-26}$	5876.31(16)	-0.015	$m_{\Xi_b^0} = m_u + m_s + m_b + \frac{2\,M}{m_u} + \frac{M}{m_s} + \frac{2\,M}{m_b}$
Bottom Xi	Ξ_b^-	dsb, bds, sbd	5797.0(6)	$1.0334 \cdot 10^{-26}$	$1.038230(45) \cdot 10^{-26}$	5824.04(25)	-0.005	$m_{\Xi_b^-} = m_d + m_s + m_b + 3N + \frac{M}{m_d} + \frac{M}{m_s} + \frac{M}{m_b}$

Bottom Xi prime	$\Xi_b'^0$	sub, bsu, ubs	unknown	---	$1.052580(29)\cdot 10^{-26}$	5904.54(16)	---	$m_{\Xi_b'^0} = m_u + m_s + m_b + \frac{2\,M}{m_u} + \frac{2\,M}{m_s} + \frac{M}{m_b}$
Bottom Xi prime	$\Xi_b'^-$	sdb, bds, sbd	unknown	---	$1.038230(45)\cdot 10^{-26}$	5824.04(25)	---	$m_{\Xi_b'^-} = m_d + m_s + m_b + 3\,N + \frac{M}{m_d} + \frac{M}{m_s} + \frac{M}{m_b}$
Double bottom Xi	Ξ_{bb}^0	ubb bub, bbu	unknown	--- ---	$1.849021(56)\cdot 10^{-26}$ $1.850084(56)\cdot 10^{-26}$	10372.24(31) 10378.21(31)	--- ---	$m_{\Xi_{bb}^0}(1) = m_u + 2\,m_b + \frac{2\,M}{m_u} + \frac{M}{m_b}$ $m_{\Xi_{bb}^0}(2) = m_u + 2\,m_b + \frac{2\,M}{m_u} + \frac{3\,M}{m_b}$
Double bottom Xi	Ξ_{bb}^-	bdb, bbd dbb	unknown	--- ---	$1.839703(66)\cdot 10^{-26}$ $1.840766(66)\cdot 10^{-26}$	10319.98(37) 10325.94(37)	--- ---	$m_{\Xi_{bb}^-}(1) = m_d + 2\,m_b + 3\,N + \frac{M}{m_d}$ $m_{\Xi_{bb}^-}(2) = m_d + 2\,m_b + 3\,N + \frac{M}{m_d} + \frac{2\,M}{m_b}$
Charmed bottom Xi	Ξ_{cb}^+	ubc, bcu cub	unknown	---	$1.236685(42)\cdot 10^{-26}$ $1.25256(16)\cdot 10^{-26}$	6937.29(24) 7026.35(90)	--- ---	$m_{\Xi_{cb}^+}(1) = m_u + m_b + m_c + 3\,N + \frac{2\,M}{m_u} + \frac{2\,M}{m_b} + \frac{4\,M}{m_c}$ $m_{\Xi_{cb}^+}(2) = m_u + m_b + m_c + 15\,N + \frac{2\,M}{m_u} + \frac{2\,M}{m_b} + \frac{4\,M}{m_c}$
Charmed bottom Xi	Ξ_{cb}^0	dbc, cdb, bcd	unknown	---	$1.216432(34)\cdot 10^{-26}$	6823.68(19)	---	$m_{\Xi_{cb}^0} = m_d + m_b + m_c + \frac{M}{m_d} + \frac{2\,M}{m_b} + \frac{2\,M}{m_c}$
Charmed bottom Xi prime	$\Xi_{cb}'^+$	buc, cbu ucb	unknown	---	$1.258625(43)\cdot 10^{-26}$ $1.27450(16)\cdot 10^{-26}$	7060.37(24) 7149.42(90)	--- ---	$m_{\Xi_{cb}'^+}(1) = m_c + m_u + m_b + 3\,N + \frac{4\,M}{m_u} + \frac{2\,M}{m_c} + \frac{2\,M}{m_b}$ $m_{\Xi_{cb}'^+}(2) = m_c + m_u + m_b + 15\,N + \frac{4\,M}{m_u} + \frac{2\,M}{m_c} + \frac{2\,M}{m_b}$
Charmed bottom Xi prime	$\Xi_{cb}'^0$	dcb, cbd, dcb	unknown	---	$1.228645(29)\cdot 10^{-26}$	6892.19(16)	---	$m_{\Xi_{cb}'^0} = m_d + m_b + m_c + \frac{2\,M}{m_d} + \frac{M}{m_b} + \frac{2\,M}{m_c}$
Charmed Omega	Ω_c^0	css ssc, scs	2695.2(1.2)	$4.8046\cdot 10^{-27}$	$4.486776(34)\cdot 10^{-27}$ $4.598069(39)\cdot 10^{-27}$	2516.897(19) 2579.327(22)	0.066 0.043	$m_{\Omega_c^0}(1) = m_c + 2\,m_s + \frac{2\,M}{m_c} + \frac{M}{m_s}$ $m_{\Omega_c^0}(2) = m_c + 2\,m_s + \frac{2\,M}{m_c} + \frac{3\,M}{m_s}$
Bottom Omega	Ω_b^-	ssb, sbs bss	6046.1(1.7)	$1.0778\cdot 10^{-26}$	$1.067979(41)\cdot 10^{-26}$ $1.079108(41)\cdot 10^{-26}$	5990.92(23) 6053.35(23)	0.009 -0.001	$m_{\Omega_b^-}(1) = 2\,m_s + m_b + 3\,N + \frac{M}{m_b}$ $m_{\Omega_b^-}(2) = 2\,m_s + m_b + 3\,N + \frac{2\,M}{m_s} + \frac{M}{m_b}$
Double charmed Omega	Ω_{cc}^+	scc csc ccs	unknown	--- --- ---	$6.41885(31)\cdot 10^{-27}$ $6.48944(31)\cdot 10^{-27}$ $6.6482(15)\cdot 10^{-27}$	3600.71(17) 3640.31(17) 3729.37(84)	--- --- ---	$\Omega_{cc}^+(1) = m_s + 2\,m_c + 3\,N + \frac{2\,M}{m_s} + \frac{2\,M}{m_c}$ $\Omega_{cc}^+(2) = m_s + 2\,m_c + 3\,N + \frac{2\,M}{m_s} + \frac{6\,M}{m_c}$ $\Omega_{cc}^+(3) = m_s + 2\,m_c + 15\,N + \frac{2\,M}{m_s} + \frac{6\,M}{m_c}$
Charmed bottom Omega	Ω_{cb}^0	sbc, bcs, csb	unknown	---	$1.257310(28)\cdot 10^{-26}$	7052.99(16)	---	$m_{\Omega_{cb}^0} = m_s + m_b + m_c + \frac{M}{m_s} + \frac{2\,M}{m_b} + \frac{2\,M}{m_c}$
Charmed bottom	$\Omega_{cb}'^0$	scb, cbs, bsc	unknown	---	$1.262343(28)\cdot 10^{-26}$	7081.22(16)	---	$m_{\Omega_{cb}'^0} = m_s + m_b + m_c + \frac{2\,M}{m_s} + \frac{M}{m_b} + \frac{2\,M}{m_c}$

Omega prime								
Double bottom Omega	Ω_{bb}^{-}	bsb, bbs sbb	unknown	--- ---	$1.880581(63) \cdot 10^{-26}$ $1.881645(63) \cdot 10^{-26}$	10549.29(35) 10555.25(35)	--- ---	$m_{\Omega_{bb}^{-}}(1) = m_s + 2\,m_b + 3\,N + \frac{M}{m_s}$ $m_{\Omega_{bb}^{-}}(2) = m_s + 2\,m_b + 3\,N + \frac{M}{m_s} + \frac{2\,M}{m_b}$
Double charmed bottom Omega	Ω_{ccb}^{+}	bcc cbc ccb	unknown	--- --- ---	$1.439388(41) \cdot 10^{-26}$ $1.446447(41) \cdot 10^{-26}$ $1.46232(15) \cdot 10^{-26}$	8074.37(23) 8113.97(23) 8203.01(84)	--- --- ---	$m_{\Omega_{ccb}^{+}}(1) = 2\,m_c + m_b + 3\,N + \frac{2\,M}{m_c} + \frac{2\,M}{m_b}$ $m_{\Omega_{ccb}^{+}}(2) = 2\,m_c + m_b + 3\,N + \frac{6\,M}{m_c} + \frac{2\,M}{m_b}$ $m_{\Omega_{ccb}^{+}}(3) = 2\,m_c + m_b + 15\,N + \frac{6\,M}{m_c} + \frac{2\,M}{m_b}$
Charmed double bottom Omega	Ω_{cbb}^{0}	cbb bbc, bcb	unknown	--- ---	$2.058784(55) \cdot 10^{-26}$ $2.059847(55) \cdot 10^{-26}$	11548.93(31) 11554.89(31)	--- ---	$m_{\Omega_{cbb}^{0}}(1) = m_c + 2\,m_b + \frac{2\,M}{m_c} + \frac{M}{m_b}$ $m_{\Omega_{cbb}^{0}}(2) = m_c + 2\,m_b + \frac{2\,M}{m_c} + \frac{3\,M}{m_b}$
		tdd ddt, dtd	unknown	--- ---	$3.0885(53) \cdot 10^{-25}$ $3.0910(53) \cdot 10^{-25}$	173252.(297.) 173392.(297.)	--- ---	$m_{tdd}(1) = 2\,m_d + m_t + \frac{M}{m_d} + \frac{2\,M}{m_t}$ $m_{tdd}(2) = 2\,m_d + m_t + \frac{3\,M}{m_d} + \frac{2\,M}{m_t}$

Discussion

The Standard Model describes particles by quantum numbers in terms of charge, spin, isospin etc. While a direct connection to the excitation numbers is obvious, each number is directly connected to the strong, electric, or weak charges and to spin. Excitations evolving naturally within the framework of the 10-dimensional space-time with 6 compactified dimensions, are responsible for the main fraction of mass. A substantial contribution to the particle mass, at least for the light quarks, results from magnetism. However, there appears to be subtle mass contributing mechanisms that are still lacking. When calculating the magnetic constants N, M and the strong coupling α_s, three out of four first generation meson masses and their respective equations (82), are needed. Depending on the selection of the mesons, the numerical values of the constants and the strong coupling vary slightly. Nevertheless, calculating the masses of the composite particles mesons and baryons (**Tables 5 to 8**) produces sensible results. A detailed knowledge of the metric tensor and the γ-factors of the quarks, relative to the hadron's center of mass system is not necessary for the calculation. By combining the rest energy, the kinetic energy, and the potential energy, the terms containing those expressions cancel. In most cases, the relative errors between measured and calculated masses are smaller than 0.05, albeit with some exceptions. The largest difference is found with the Δ^{++} baryon, with spin $3\hbar/2$. It has a calculated mass of approximately 112% higher than the measured value. This could be caused by the mass measurement, which does not discriminate between the delta mesons with a different electric charge. Nonetheless, it seems that the extremely high magnetic field strength of this triple up quark arrangement combines differently than other baryons with a lower field strength. Something similar can be observed with the charmed sigma double plus Σ_c^{++}, which has an identical magnetic field strength. The quark content is uuc, hence the relative influence of its magnetic field on the mass is smaller, and has a deviation of 36%. A lot of mass results come with the spin $\hbar/2$ baryons, while the quark content is the same. For example, when comparing the Λ^0 to Σ^0, both have the same quark content of dsu, but with different mass. The mass of the quark combination duu deviates from the measured proton mass by 0.3% while the difference for uud is 40%, and 30% for udu. In other cases of identical quark content, there are different mass values, which are very close to each other e.g., the masses of the three ddu combinations are similar, but are as much as 10% off the measured value of the neutron. The average, however, deviates by only 0.3%. For establishing the experimental mass data, are their results averaged and interpreted as one mass? Or is the neutron a superposition of the three ddu combinations?

There are questions that have gone unanswered. Are subtle additional mechanisms at work that have not been mentioned here? Could it be color or weak magnetism? If the contributions from the various dimensions add up, color magnetism would cancel out. Weak magnetism, however, could contribute to the mass. While this is indeed a speculative question, it is, notwithstanding, worth pursuing.

During the developmental process of the model, it was not only possible but also necessary to calculate some important constants: the compactification radius ρ, the weak α_w and the strong α_s coupling and δ the neutrino distribution ratio. δ evolves from the two compactified dimensions responsible for the weak interaction with a logarithmic dependency on the mean distance to the neutrino/anti-neutrino. In this context δ is responsible for the extremely low neutrino mass. Therefore, the estimate for the neutrino's upper mass border from the maximal possible mass difference between positron and electron, is $m_{\nu_e} = -\frac{2\hbar}{c\rho} \cdot \alpha_w \, ln(\delta) = 0.001 \, \frac{eV}{c^2}$, for the lightest neutrino. It is not clear what the mass of the second or third generation neutrino might be. By taking into account the number received for m_{ν_e} is the upper bound, the value appears to be in agreement with the upper limits of $1.1\ \frac{eV}{c^2}$ reported by the KATRINA collaboration [41], or the $0.33\ \frac{eV}{c^2}$ of the astrophysical Chandra observations [42]. However, additional experimental verification is needed. Could there be areas in space with a different neutrino to anti-neutrino distribution? And can this difference be measured? The particle mass, e.g., of the electron, would change slightly, as would the magnetic moment. In the calculation above, using the mass data from PDG [29] for e^- and e^+, the smaller δ value was used, which means the number of anti-neutrinos is smaller than the one of neutrinos. As a consequence the neutrino mass is positive and the anti-neutrino mass negative. The overall combined mass of neutinos and anti-neutrinos is likewise positive. In the event of a higher number of anti-neutrinos compared to neutinos, the neutrino mass would be negative and the mass of anti-neutrinos positive. The overall mass of neutinos and anti-neutrinos would remain positive.

In the context of this paper, the couplings play the roles of constants, since mesons and baryons are described in its 'stable' situation and not in the process of decay. This does not mean that quarks and anti-quarks exist in a static configuration. Quite the opposite is true. The hadrons' masses arise as "solid" due to the counterbalance between kinetic and the potential energies connected to strong, electric, and weak interaction.

The tensor calculus of general relativity is used, but it is not necessary to expect the 10D space-time to be a smooth canvas. The averaging processes might mimic smoothness, which for small time intervals $\ll 10^{-24}s$ and small distances $\ll 10^{-15}m$ might not hold true. When analyzing the dynamic processes in curved space-time, the model also promises a further understanding of decay processes, in which the metric tensor plays a major role. This, however, is a non-trivial endeavor. The starting point of such calculations is the metric tensor, which can be calculated using equation (3). Here the radii of the compactified dimensions as functions of the distance between two particles needs to be known. But, the radii, in the most general case, depend on the metric tensor and on the velocity of the particle. The interesting physics happens when particles are in close distance (up to a few femtometer) to each other. While g_{11} is ≈ -1 for distances $z > 10^3$, for smaller distances it is not! The problem with calculating the metric tensor from the dynamically changing radii of the compactified dimensions is that the metric tensor is part of the expression describing the radii. Numerical approaches might allow some further insight. To get a first impression of what the analysis of a decay process can look like, the dynamics of a $d\bar{d}$ combination – part of the pion superposition - is displayed. Here, major simplifications take place: 1. The weak interaction is omitted in the calculation. This might be a problem for smaller distances $z < 0.1$, because the weak force becomes substantial. 2. All dependencies on the metric tensor $g_{\mu\nu}$ and on the γ-factor are dropped. The resulting d quark's velocity and acceleration are displayed in **Figure 5**.

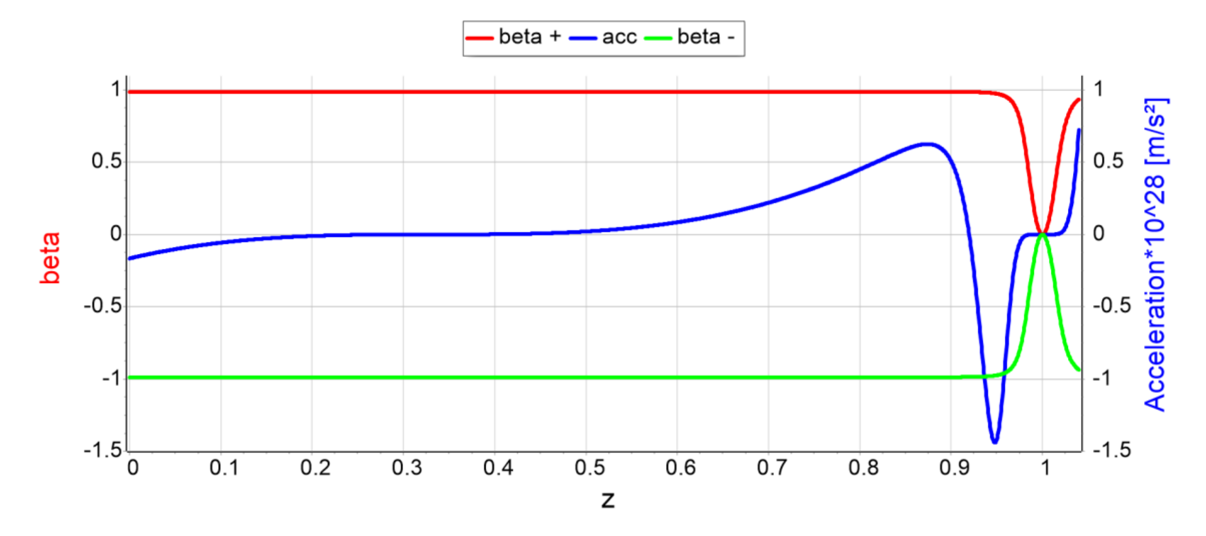

Figure 5: Normalized velocity β and acceleration of a d-quark within a $d\bar{d}$ combination

β never reaches 1 or -1. For $z = 1$ the acceleration and β are both zero. Here the decay process would read as "when does the particle leave the binding?" This would depend on the excitation numbers and on the fluctuations caused by the smoothness/noisiness of space-time.

Conclusion

This model consists of a 10-dimensional construct, with the usual 4-dimensional space-time and 6 compactified dimensions. Excitations, temporary deformations always travel with the speed of light. Excitations on the compactified dimensions form stable waves with a wavelength $\lambda = \frac{4\,\pi\,r}{o}$, and with r: radius of the compact dimension, and o: an integer, the excitation number. The energy of such a construct is in accordance with Louis de Broglie's interpretation of wave mechanics [43] $E = \hbar \cdot \omega = \frac{c\,\hbar\,o}{r}$. This energy and the contribution from magnetism is the reason for the matter measured in 4D space-time. In general, within this model, all energy/matter and dynamics are manifestations of the excitations acting on the 10D structure. The undisturbed radii of the compactified dimensions are: $\frac{\rho}{\alpha_s}$ for the strong; $\frac{9\rho}{\alpha_e}$ for the electric; and, $\frac{\rho}{\alpha_w}$ for the weak interaction with ρ being the compactification radius. Within the model, the constants, the most important to mention are $\rho, \alpha_w, \alpha_s, \delta$, were calculated by means of the measured masses of the leptons, the particles $\pi^0, \pi^+, \rho^0, \phi, \psi, \Upsilon$, the top-quark mass m_t and the anomalous magnetic dipole moment g. Once this was completed, the hadron masses were calculated. This data can be found in the **Tables 5 to 8**. The masses induced by the excitations of the weak interaction are influenced by the proximity of neutrinos and anti-neutrinos. On the other hand, the mixing ratio directly and minimally effects the particle masses of hadrons and charged leptons, while dominating the neutrino masses. The particle masses do provide some information on the neutrino/anti-neutrino distribution. Further, it seems the model has the potential for analyzing the creation and decay processes of particles without the use of Feynman diagrams [44]. This formulation of a Kaluza-Klein like model should not be viewed as rivaling the Standard Model of Particle Physics, rather it should be seen as a different view of the same thing: namely Particle Physics.

Appendix

Parameters used in the calculations

The newly established system constants are ρ: compactification radius, α_w: weak coupling, α_s: strong coupling, δ: neutrino distribution ratio, M & N: magnetic constants, $A_{d,u,s,c,b,t}$: flavor constants, $A_{e,\mu,\tau,\nu_e,\nu_\mu,\nu_\tau}$: lepton constants. To calculate these constants the measured masses **(Table 11)** of the leptons and following mesons are used π^0, π^+, ρ^0, ϕ, ψ, Υ, the top-quark mass m_t and the anomalous magnetic dipole moment g **(Table 12)**. The deviations of the calculated constants, quark and hadron masses were obtained using Gauss error propagation (86).

$$s_Z = \sqrt{\left(\frac{\partial Z}{\partial a}\right)^2 \cdot s_a^2 + \left(\frac{\partial Z}{\partial b}\right)^2 \cdot s_b^2 + \cdots} \tag{86}$$

Equation (86) is used to compute the standard deviation of a quantity Z, which is calculated from parameters given as the mean values $a, b, \ldots$ and standard deviations $s_a, s_b, \ldots$ for the numerical result of equations (65), (70), (71), **Tables 1, 2,** and **5** to **10**.

Table 9: List of calculated system constants

Name	Symbol	Value	Input parameters
Compactification radius	ρ	$9.4040252(14) \cdot 10^{-16} m$	g, α_e, m_{e^-}
Weak coupling	α_w	$1.41040(26) \cdot 10^{-6}$	$m_{e^-}, m_{e^+}, \rho, \alpha_e$
Neutrino distance ratio $\delta = z_\nu / \bar{z}_\nu = \sqrt[3]{\rho_{\bar{\nu}}/\rho_\nu}$	δ	$1.0000034530(64)$ if $m_{e^+} < m_{e^-}$ $0.9999965467(64)$ if $m_{e^+} > m_{e^-}$	$m_{e^-}, m_{e^+}, \rho, \alpha_e$
Strong coupling	α_s	$0.49743(39)$	$m_{\pi^0}, m_{\pi^+}, m_{\rho^0}, \alpha_e, \alpha_w, \delta$
Magnetic moment's constant	M	$4.74681(57) \cdot 10^{-56} kg^2$	$m_{\pi^0}, m_{\pi^+}, m_{\rho^0}, \alpha_e, \alpha_w, \delta$
Magnetic field's constant	N	$1.323(10) \cdot 10^{-29} kg$	$m_{\pi^0}, m_{\pi^+}, m_{\rho^0}, \alpha_e, \alpha_w, \delta$
Electron constant	A_e	0	
Electron neutrino constant	A_{ν_e}	0	
Muon constant	A_μ	$0.33561(26)$	m_μ
Muon neutrino constant	A_{ν_μ}	unknown	
Tau constant	A_τ	$5.6698(44)$	m_τ
Tau neutrino constant	A_{ν_τ}	unknown	
d-flavor constant	A_d	0	
u-flavor constant	A_u	0	
s-flavor constant	A_s	$0.86050(84)$	m_ϕ
c-flavor constant	A_c	$4.14863(52)$	m_ψ
b-flavor constant	A_b	$15.320(12)$	m_Υ
t-flavor constant	A_t	$550.8(1.0)$	Calculated using m_t of [29]

Table 10: List of quark masses (without contributions of magnetism)

Calculated d, u, s, c, b and measured t masses		Mass [kg]	Mass [MeV/c²]
Quark and anti-quark	m_d	$3.7244(29) \cdot 10^{-28}$	208.92(16)
masses without magnetic	$m_{\bar{d}}$	$3.7244(29) \cdot 10^{-28}$	208.92(16)
contribution.	m_u	$3.7274(29) \cdot 10^{-28}$	209.09(16)
	$m_{\bar{u}}$	$3.7274(29) \cdot 10^{-28}$	209.09(16)
	m_s	$8.53031(17) \cdot 10^{-28}$	478.5153(95)
Although quarks and anti-	$m_{\bar{s}}$	$8.53031(17) \cdot 10^{-28}$	478.5153(95)
quarks differ in mass, this	m_c	$2.689772(10) \cdot 10^{-27}$	1508.851(56)

difference is below the deviation resulting from the parameters inaccuracy of the input.	$m_{\bar{c}}$	$2.689772(10) \cdot 10^{-27}$	1508.851(56)
	m_b	$8.92873(28) \cdot 10^{-27}$	5008.650(16)
	$m_{\bar{b}}$	$8.92873(28) \cdot 10^{-27}$	5008.650(16)
	m_t	$3.0797(53) \cdot 10^{-25}$	172760(300)
	$m_{\bar{t}}$	$3.0797(53) \cdot 10^{-25}$	172760(300)

Table 11: List of measured particle masses used in the calculations [29]

Measured particle masses used in the calculation		Mass [kg]	Mass [MeV/c²]
Electron/Positron	e	$9.109384033(55) \cdot 10^{-31}$	0.5109989461(31)
Muon	μ	$1.883531692(43) \cdot 10^{-28}$	105.6583745(24)
Tau	τ	$3.16754(21) \cdot 10^{-27}$	1776.86(12)
Pion⁰	π^0	$2.4061801(89) \cdot 10^{-28}$	134.9768(5)
Pion⁺	π^+	$2.4880683(32) \cdot 10^{-28}$	139.57039(18)
Rho⁰	ρ^0	$1.38203(41) \cdot 10^{-27}$	775.26(23)
Phi	ϕ	$1.817354(29) \cdot 10^{-27}$	1019.461(16)
J/Psi	J/ψ	$5.520726(11) \cdot 10^{-27}$	3096.900(6)
Upsilon	Υ	$1.786808(55) \cdot 10^{-26}$	10023.26(31)

Table 12: Constants from literature used in the calculations [29]

Name	Symbol	Value
Speed of light	c	$299792458\ m/s$
Reduced Planck constant	$\hbar = \frac{h}{2\pi}$	$1.054571817 \cdot 10^{-34} Js$
Anomalous magnetic dipole moment	g	$2.00231930436182(52)$
Electric coupling	α_e	$7.2973525693(11) \cdot 10^{-3}$

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