A Theory of the Muon; Explaining the Electron's Embarrassing Fat Cousin!

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Abstract

A theory of the muon is presented that explains the mass of the muon from a formula derived from the relativistic wave equations independently discovered by Lanczos, Weyl, and Van der Waarden using the Liénard-Wiechert potential, discussed in the appendix. The mean-life of the muon is also calculated in a way that differs from the beta-decay-like standard model mechanism but uses a spontaneous emission-like model using Heisenberg's spontaneous emission formula and the model of Weinberg and Salam with the Z^0 Boson playing a role analogous to the photon.

Part I

Introduction

The muon, was discovered in 1936 at Cal tech by Carl D. Anderson and Seth Neddermeyer[1] and confirmed by J. Street, and E. Stevenson in 1937[2]. At first it was misidentified as a nuclear force carrying particle, in a theory presented by H. Yukawa[3]. After it was discovered that the muon was not Yukawa's particle, I.I. Rabi[4] famously questioned:

> ***"Who ordered that?"***

The Muon was seen to be the electron's embarrassing fat cousin; embarrassing because it was a reminder that we really do not understand what is going on! Richard Feynman[5] in a discussion of the "loose ends" of Physics said of the muon:

> ***"One such particle was the muon, which is in every way exactly the same as the electron , except that its mass is much higher-105.8" (actually closer to 105.66)"compared to 0.511 for the electron, or about 206 times heavier. It's***

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just as if God wanted to try out a different number for the mass! All of the properties of the muon" (except the mass and mean life)" are completely describable by the theory of electrodynamics"

This presentation hopes to present an explanation of both the mass and mean life of the muon that will be acceptable to the physics community.

Part II
The Birth of a Muon-Origin of its Mass

1 Mass Formula

A formula was obtained from a quantum mechanical relativistic wave equation discovered in various forms by Lanczos[6], Weyl[7] and Van der Waarden[8] and the quantized Liénard Wiechert potential[9]. This was first presented in a refereed publication[1] in the author's Doctoral Dissertation[10]. The method[2] uses the Pauli algebra representation of Hamilton's biquaternions[11].

The derivation of said formula, is somewhat complicated, so that the reader is asked to, at first, treat the following formula as spectroscopists treated the empirical Balmer formula after its discovery in 1885[12] and its generalization by Rydberg in 1888[13]. Although, other formulae for predicting particle masses have been presented, the formula presented here and its generalization[3] are more extensive being used for Leptons, Hadrons, Intermediate vector Bosons and Higgs Boson, while also giving an error of less than 1% for all particles.

[1] L.C#Tx 2 817 286 ©1988 ©1990 SJK, shown to Victor Weisskopf in June 1990 at MIT also to Kerson Huang at "Viki's" suggestion, then submitted to but not accepted Physical Review Letters manuscript # LD5183 June 1993.. Dissertation research supported in part by United States Air Force. Accepted for publication by referees Gsponner and Hurni to the Ukrainian Journal "Electromagnetic Phenomena", however Russian Guest editor could not read the version of Latex that was submitted and the paper never appeared.

[2] The formula presented and a generalization, to be presented later, explain the mass of all the particles of the Gell-Man and Zweig quark model the leptons, and the $W^{\pm}Z^{0}$and Higgs particle.

[3] See Appendix

The formula, for mass gained due to short ranged electromagnetism, which only involves quantum and electromagnetic quantities is

$$M = \frac{m_e}{\alpha |q_s||q_t|(1 \pm \delta_n)} \tag{1}$$

where,

$$m_e = electron\, mass \cong .511 \frac{Mev}{c^2}$$

$$\alpha = fine\; structure\; constant\; \cong \frac{1}{137.036}$$

$$|q_s| = absolute\; value\; of\; (source\; charge/electron\; charge) i.e. (1, \frac{1}{3}, \frac{2}{3})$$

$$|q_t| = absolute\; value\; of\; (test\; charge/electron\; charge) i.e. (1, \frac{1}{3}, \frac{2}{3}),$$

$$\delta_n = small\;\; magnetic\;\; correction, \delta_n = 0, .00457, .00914, .03$$

In order to demonstrate that this formula works for all non-strange particles in the Gell Mann/ Zweig quark model the reader is referred to Appendix A.

2 Pion Decay to Muon Creation

The muon is known to be a decay product of a pion. A positively charged pion according to the Gell Mann[14]/ Zweig[15] quark model is composed of an up quark and a down antiquark. To decay into a positively charged muon the a down antiquark must beta decay to an up antiquark a neutrino and a positron. See Figure 1. (The process for a negative muon replaces all particles with their anti particles.) In the positive pion to positive muon decay the beta decay positron with $|q_t| = 1$ gains extra mass by its short range interaction with the up quark(or the beta decayed up antiquark) with$|q_s| = \frac{2}{3}$ magnetic corrections are ignored so that δ_n=0. After the positron gains mass the up quark and up antiquark annihilate and the positron has the mass given below.

$$M_\mu = \frac{m_e}{\alpha |q_s||q_t|} + m_e \tag{2}$$

$$M_\mu = \frac{137.036 * 0.510998928\; MeV/c^2}{\frac{2}{3} * 1} + 0.510998928 MeV/c^2 = 105.548 MeV/c^2 \tag{3}$$

This compares with the observed value of 105.658 MeV/c^2[16] being 0.1% different.

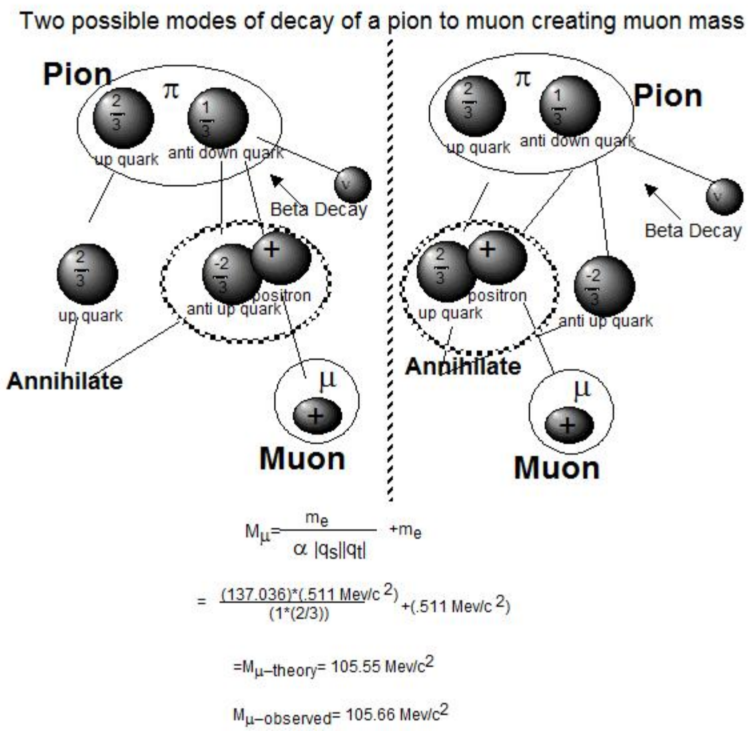


Figure 1. Creation of a muon in decay of a pion. Beta decay of anti down quark to anti up quark causes the created positron to gain mass by a close interaction with the up quark (or possibly the anti up quark) before the up quark and anti-up quark annihilate. A mass equation derived from a quantum mechanical relativistic wave equation and short range electromagnetism is used. The mass creating mechanism is shown inside the enclosed dashed lines.

3 Muon Mass Calculated Results Compared to Observation

Calculated muon mass	Observed muon mass
$M_{muon-calc} = 105.548\, MeV/c^2$	$M_{muon-observed} = 105.658\, MeV/c^2$[16]

Part III

Death of a Muon-Calculation of Its Mean Life

4 Critique of Standard "Beta Decay" Model Treatment of Muon Decay

In the standard treatment, the muon was assumed to decay as a beta decay, like a neutron decaying to a proton, electron and neutrino as shown in figure 2.

The standard model claims the muon mean life is $\tau_\mu = \dfrac{192\pi^3\hbar^7}{G_F^2 m_\mu^5 c^4}$[17]where $G_F = Fermi$ [17]Coupling Constant. The main criticism of this method is that the experimental value of the muon mean life is used to calculate G_F , getting a value of $G_{F-\mu} = 1.16639 \times 10^{-11} Mev^{-2} \times (\hbar c)^3$. The coupling constant can, however, be calculated using nuclear beta decays[18] but the methods are complicated and less precise than using the assumption that the muon decays via "beta decay". It is not clear if methods that incorporate nuclear beta decay data to calculate the Fermi coupling constant G_F are totally independent of muon decay data.

Other methods [19]of measuring G_F based on Astronomical measurements yield possible errors of 10% and 40% in the calculated value of the muon mean life from the observed mean life.

The Intermediate Vector Boson model of Glashow[20][4], later extended by Salam and Weinberg[21][22], is used in the standard explanation for the muon mean life. It is claimed in the Standard Model that a $\pm$muon ejects a $W^\pm$and changes to a $\mu - neutrino$ then the$W^\pm$decays to a $\pm$ electron and an electron neutrino/or anti-electron neutrino. This is depicted in Figure 2. for a negative muon to electron. This is analogous to the free neutron decay shown in the inset of Figure 2.

[4] Ph.D. project assigned by his advisor Julian Schwinger, original idea usually attributed to Oskar Klein

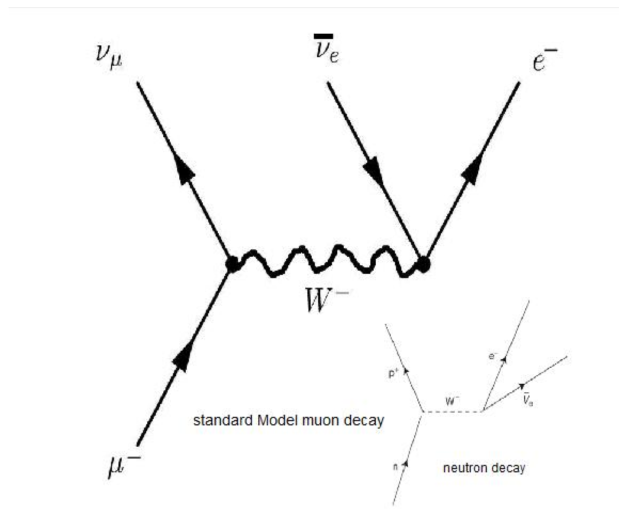


Figure 2. Above is the standard model"beta-decay-like model" for muon decay. Muon decay was characterized as being like the beta decay of a neutron, shown in lower right inset. The alternative Z^0Boson spontaneous-emission-like model theory presented below claims that Figure 3. is the correct depiction of how a muon decays not the above depiction.

5 Muon Decay as Analogous to Photon Spontaneous Emission.

5.1 Background

According to the Weinberg-Salam [21][22]theory in addition to the charged massive "messenger" particles, $W^{\pm}$ as Salam called them, another massive neutral "messenger" particle the $Z^0$was added to what was originally Sheldon Glashow's Intermediate Vector Boson (IVB) Theory. They joined the rest-mass less Photon, γ, as "messenger" or force carrying particles. The photon plays a duel role in quantum electrodynamics. The first role is radiation, commonly refereed to as light, . The second role is that of force carrier[23]. If the Z^0particle in addition to its force associated duties, also has a short range radiation role that takes place before it decays, then it is possible that the muon might might decay via a spontaneous emission [24][25] that is identical to photon spontaneous emission where the Z^0 takes the place of the spontaneous emission photon, γ. It turns out that there is enough experimental information to test this hypothesis. The physical situation is depicted in a quasi Feynman Diagram in Figure 3. The diagram Shows a +Muon emitting a Z^0 particle and becoming a +electron (i.e. a positron) in analogy to an excited atom spontaneously emitting a photon.

Additional photons, related to the charged muon going to a different-velocity lower-massed charged +electron, are shown as a normal electromagnetic radiative correction . When analyzed in a center of mass co-ordinate system, the electron has approximately the same energy and opposite momentum as the two neutrinos. The energy spectrum of the decay electron/positron for the muon is estimated to have a maxima at about 49.8 Mev [27]see figure 4.

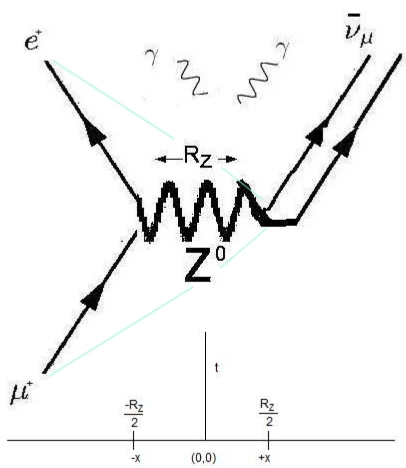


Figure 3. The darker lines represent a dipole-like spontaneous emission of a Z^0 boson, playing the role of a photon, being emitted from a +muon which then becomes a positron (+electron). It could also be interpreted that the +muon was a higher state of the +electron analogous to an excited atom emitting a photon and becoming a slightly-less-massive not-as-excited atom . This suggests an internal structure of the electron-muon which will be discussed elsewhere. The thinner lines are used to explain the calculation of the matrix element needed to calculate the the life time of the muon using Heisenberg's dipole spontaneous emission formula [24]. This avoids the beta-decay model and Fermi coupling constant depicted in figure 2. The gamma's,γ and γ , represent normal electromagnetic radiation emitted due to acceleration of the charged positron. The x-axis is horizontal and time axis is vertical. Lighter trajectory line shows uncertainty of positions due to Z^0.

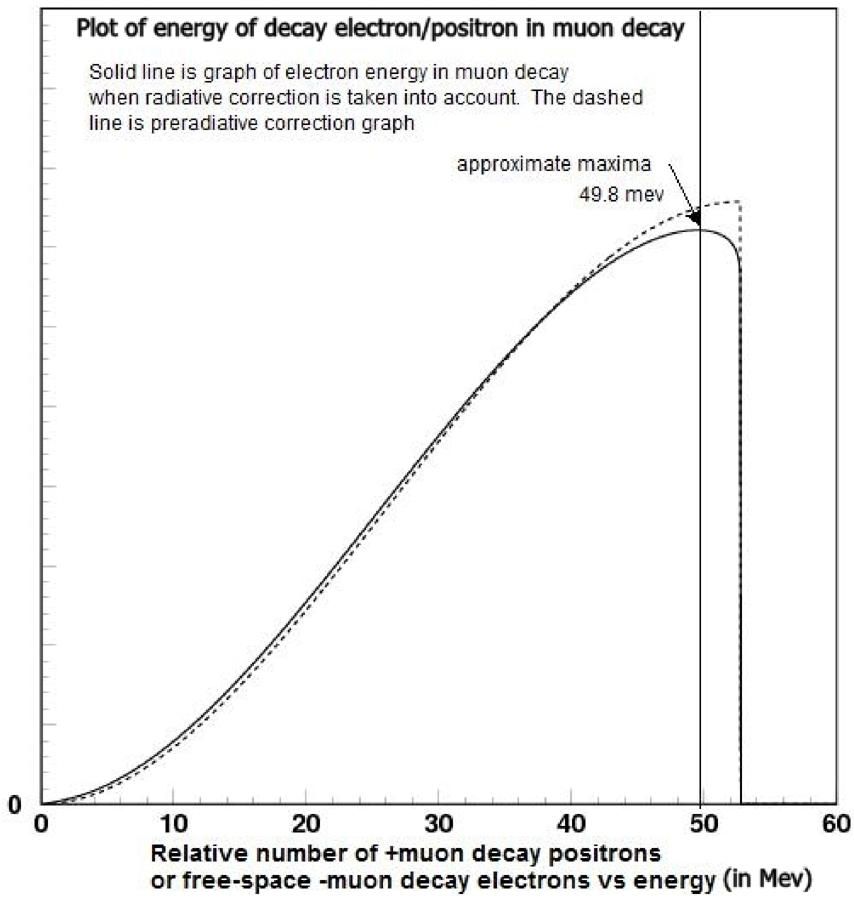


Figure 4. Relative number of muon decay electrons/positrons as a function of Energy in Mev. Maxima at about 49.8 Mev[26]. The formula for the transition rate for spontaneous emission of photons when inverted yields the mean life of an excited state.

5.2 Using Heisenberg's [24]spontaneous emission formula for Z^0"spontaneous"emission

Inverting the standard formula[24][25]due to Heisenberg[24], testing the hypothesis that the muon decays like an excited state of the $\pm electron$ yields;

$$\tau_{muon} = \frac{3}{4}\frac{\hbar^4 c^3}{ke^2}\frac{1}{E^3}\frac{1}{|<\Psi_\mu|x|\Psi_e>|^2} \tag{4}$$

where

$$\frac{\hbar c}{ke^2} = \frac{1}{\alpha} \backsimeq 137.036$$

$$\hbar \backsimeq 6.582 \times 10^{-22} Mev \bullet s$$

$$c \backsimeq 2.99792 \times 10^{10}\frac{cm}{s}$$

$$E \backsimeq 49.8 Mev$$

[26]

$$<\Psi_\mu|x|\Psi_e> = dipole\ transition\ matrix\ element$$

The calculation will be done in the center of mass frame where the muon (pre-decay) is at x=0, the $Z^0$is emitted but its existence in the

+x direction is governed by the most stringent form of the uncertainty principle $\Delta x \Delta(mv) = \frac{\hbar}{2}$ which implies that, when $v = c$ like the photon,$\Delta(mv) = M_{Z^0}c$that $\Delta x = \frac{R_z}{2} = \frac{\hbar}{2M_{Z^0}c} \Rightarrow R_z = \frac{\hbar}{M_{Z^0}c}$ which says that the position and uncertainty of the Z^0 boson's position are $x = 0 \pm \frac{R_z}{2}$ as depicted in Figure 3.

To calculate the matrix element the plane wave functions for the +muon and +electron are used but they are only assumed to co-exist over

the distance $R_z = \frac{\hbar}{M_{Z^0}c}$with M_{Z^0} the mass of the Z^0 Boson with the currently observed mass being $M_{Z^0} = 91,187.6 Mev/c^2$ [16]. The matrix element $<\Psi_e|x|\Psi_\mu>$is only meaningful over the distance $\frac{R_z}{2} \geq x \geq \frac{-R_z}{2}$, taking $\Psi_e = \frac{e^{(-i2\pi\frac{x}{\lambda_e})}}{\sqrt{(AR_z)}}$,$\Psi_\mu = \frac{e^{(-i2\pi\frac{x}{\lambda_\mu})}}{\sqrt{(AR_z)}}$ where A is a transverse area which will cancel so that it won't be specified.Plugging in the known values of physical constants and empirical Masses/Energies[16][26]yields:

$$R_z = \frac{\hbar}{M_{Z^0}c} = \frac{6.582 \times 10^{-22} Mev \bullet s * 2.99792 \times 10^{10}\frac{cm}{s}}{91,187.6 Mev} = 2.1639 \times 10^{-16} cm$$

$$\lambda_e = \frac{2\pi\hbar c}{E_e} = \frac{2 * \pi * 6.582 \times 10^{-22} Mev \bullet s * 2.99792 \times 10^{10} \frac{cm}{s}}{49.8 Mev} = 2.4895 \times 10^{-12} cm$$

The Center of Mass system the muon has zero velocity so therefore zero momentum therefore:

$$\Psi_\mu \simeq \frac{1}{\sqrt{(AR_z)}},$$

Since $\lambda_e >> R_z$only first two terms of Taylor series expansion of $\Psi_e$is needed and therefore:

$$\Psi_e \simeq \frac{(1 + 2\pi i \frac{x}{\lambda_e})}{\sqrt{(AR_z)}}$$

If zero of coordinates is centered on R_z, the transition matrix element becomes

$$< \Psi_e | x | \Psi_\mu >= \frac{1}{AR_z} \int^A dydz \int_{\frac{-R_z}{2}}^{\frac{R_z}{2}} dx\, x(1 + i2\pi \frac{x}{\lambda_e}) = \frac{\pi R_z^2}{6\lambda_e}$$

$$| < \Psi_e | x | \Psi_\mu > | = | \frac{i\pi * (2.1639 \times 10^{-16} cm)^2}{6 * 2.4895 \times 10^{-12} cm} | = 9.8482 \times 10^{-21} cm$$

The muon life time in the photon-like dipole spontaneous emission model is then,

$$\tau_{muon} = \frac{3}{4} \frac{1}{\alpha} \frac{\hbar^3}{E^3} \frac{c^2}{| < \Psi_\mu | x | \Psi_e > |^2} = \frac{3 * (137.036) * (6.582 \times 10^{-22} Mev \bullet s)^3 * (2.99792 \times 10^{10} \frac{cm}{s})^2}{4 * (49.8 Mev)^3 * (9.8482 \times 10^{-21} cm)^2} \quad (5)$$

which calculates to

$$\tau_{muon} = 2.1989 \times 10^{-6} sec$$

which compares well with the observed value of $2.1969811 \times 10^{-6} sec$

6 Calculated Mean Life of Muon compared to Observation

mean muon life calculated	mean muon life observed
$\tau_{muon-calc} = 2.1989 \times 10^{-6} sec$	$\tau_{muon-observed} = 2.1969811 \times 10^{-6} sec$[16]

Part IV
Discussion

The muon mass was calculated from a formula that also yields the masses of Hadrons containing up and down flavored quarks [see appendix]. The calculated value,105.548 $MeV/c^{\mathbf{2}}$, is 0.10 % lower than the observed value,105.658 $MeV/c^{\mathbf{2}}$, which is still larger than the believed accuracy of the observation [16]however it is believed when the spin-spin interaction between the positron and (anti) up quark is taken into account the agreement would be even closer[5]. The muon mean-life time of $2.1989\times10^{-6}sec$ compares with the observed value of $2.1969811\times10^{-6}sec$ being higher by 0.09%. An estimate of the calculated error that depends on measured values of the emitted positron energy[ref] and to a lesser degree on the Z^0's mass[16]is on the order of $\pm1\%$ which would place the calculated and observed muon life times in the same range.

An alternate method of determining Fermi's coupling constant, not related to muon decay, is needed if the decay mode depicted in figure 3 is accepted. If it turns out to be exactly equal to the "standard model" value gotten from $\tau_{muon} = \dfrac{192\pi^3\hbar^7}{G_F^2 m_\mu^5 c^4}$then the decay modes depicted in figure 2. and figure 3. must be considered equal and therefore a very strange coincidence. If the Fermi coupling constant turns out to be different, or impossible to determine, then figure 3. should depict the new standard for muon decay!

Part V
Conclusion

It is posited that a beta-decay electron or positron interacts with an up-quark or anti-upquark and gains a mass of $\dfrac{m_e}{\alpha|q_s||q_t|}$=105.037$\dfrac{Mev}{c^2}$ so that when added to

[5]The complication of calculating the spin-spin correction would complicate the pedagogical aim of this report

the original electron/positron mass of $.511\frac{Mev}{c^2}$ it yields a mass of $105.548MeV/c^{\mathbf{2}}$ which is very close to the observed value of ,105.658 $MeV/c^{\mathbf{2}}$. The energy bloated electron or positron then decays via emission of a Z^0boson in a way exactly analogous to the emission of a photon in lower energy electromagnetic processes. Heisenberg's dipole spontaneous emission formula[24][25]$\tau_{muon} = \frac{3}{4}\frac{\hbar^4 c^3}{ke^2}\frac{1}{E^3}\frac{1}{|<\Psi_\mu|x|\Psi_e>|^2}$, yields a calculated life time of $2.1989\times 10^{-6}sec$ which is very close to the observed value[16] of $2.1969811\times 10^{-6}sec$. The electron or positron then returns to its original mass of $.511\frac{Mev}{c^2}$. The answer to Rabi[4] and Feynman's[5] question is: **The electron's embarrassing fat cousin is an excited state of the electron itself!** This does suggest that the electron has an internal structure[28] with partonic constituents. This will be explained elsewhere.

Appendix A

This appendix is meant to demonstrate that the mass formula used in Equation (1) above is general enough to explain the masses of most of the important observed particles in Physics. It is part of a more general correction to "The Standard Model" which has only been published in part by the author, see above. A full publication awaits acceptance of this report. For now the reader is only asked to accept the formula as the Balmer or Rydberg formulae were accepted leading in part to the Bohr quantum theory and Quantum Mechanics.

A general equation was derived for calculating the masses of the most prominent elementary particles.

$$M = \frac{\sqrt{2^{f^2}}m_e}{\alpha|q_s||q_t|(1\pm\delta_c)} \tag{6}$$

[6]

where M=mass gained due to short range electromagnetic interaction, m_e is the mass of the electron = $.510999\ \frac{Mev}{c^2}$

$\alpha = \frac{1}{137.036}$, $|q_s|$=absolute value of source charge in units of e, $|q_t|$=absolute value of test charge in units of e

δ_c= magnetic correction to charges, associated with quantum states called "color"

f= flavor index.$f = \{0,1,2\}$

allowed values

[6]There should also be a factor of $\sqrt{n}$where n is a positive integer to account for resonances

$$|q_s|, |q_t| = \{2, 1, \frac{2}{3}, \frac{1}{3}, \frac{1}{16}, \frac{1}{18}\} \quad (7)$$

using Δ^{++} $q = 2$ electron and quark charges and measured proton weak charge, also the assumed electron weak charge $|q_{we}| \approx \dfrac{1}{16}$[29]and measured Weinberg angle times proton weak charge, the assumed neutrino weak charge$|q_{wv}| \approx \dfrac{8}{9} * \dfrac{1}{16} = \dfrac{1}{18}$[30]$|q_e| = 1$, $|q_{\Delta^{++}}| = 2$ $|q_{uq}| = \dfrac{2}{3}$ $|q_{dq}| = \dfrac{1}{3}$.

magnetic adjustment aka "color" index is$\delta_c = \{0, .00457, .00914, .03\}$

The four lowest massed "eight fold way"particles are calculated using $M = \dfrac{m_e}{\alpha |q_s||q_t|(1 \pm \delta_c)}$ eq.(1) because f=0.

The quark model is assumed. The first two calculations are the masses of the Pion and Rho mesons by colliding electron and positron beams. This was observed in 1967 by the VEPP Experiments.

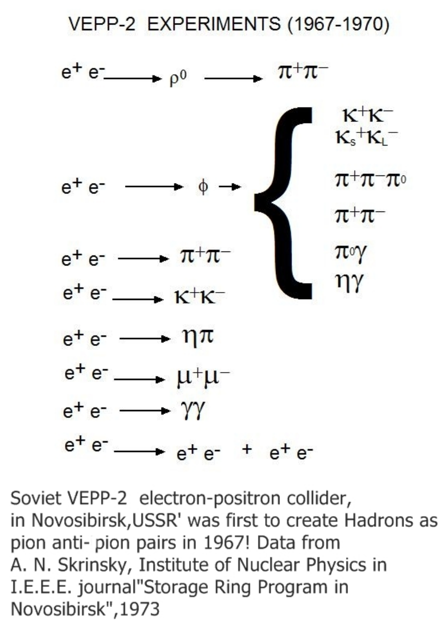


Figure A1 Experiments in Novobirsk Russia 1967-1970[27] showed that the assumed very simple electrons and positrons when colliding create the more complicated mesons. The pion,π, and the rho, ρ, meson's acquisition of mass based on the quark model and the mass formula, equation (1) or (5) are used to demonstrate the validity of the mass formula used for the muon in figures A2. and A3. below.

Pion Mass

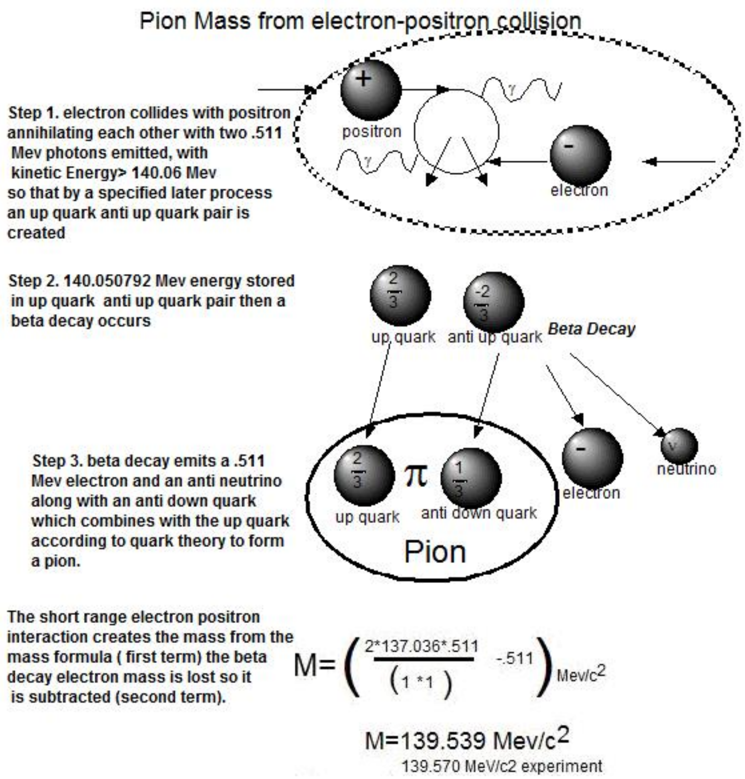


Figure A2. Creation of pion from electron positron creation first observed by VEPP 2 Experiment

Mass formula, Equation (1) yields value very close to observed value! In the above, the dashed lines around the electron and positron (after electron-positron rest mass energy radiated away in gamma photons) mark the region of mass creation from which is subtracted the beta decay electron rest mass to give a mass close to the observed value.

Rho Mass

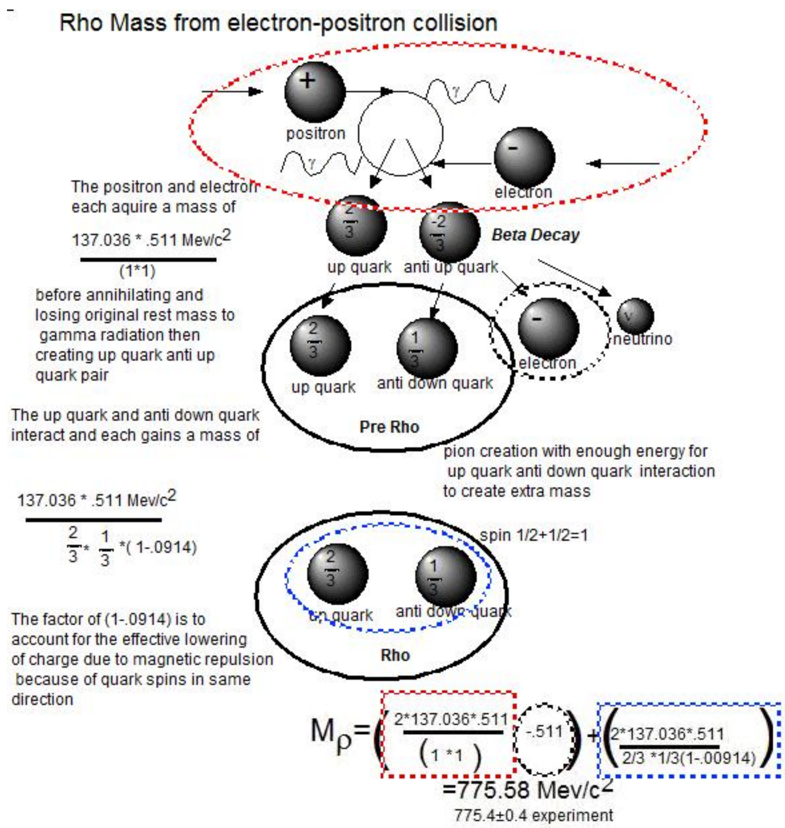
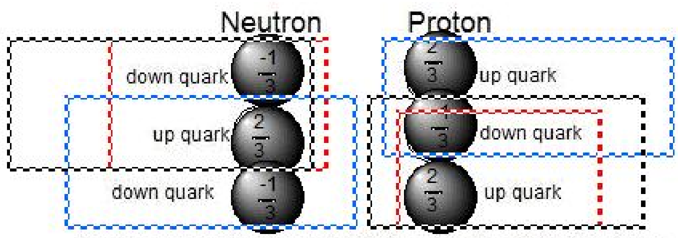


Figure A3. Creation of rho meson by electron positron collisions first observed by VEPP 2

experiment. Mass is accurately predicted by Equation (1). The dashed lines show regions where mass is created or subtracted.

Neutron Proton masses

Calculation of Neutron and Proton Masses



Assuming magnetic spin and orbital modification of effective charge

$$M_{neutron} = \left(\frac{(137.036*.511)}{\frac{1}{3}*\frac{2}{3}(1+.00457)} + \frac{(137.036*.511)}{\frac{2}{3}*\frac{1}{3}(1+.00914)} + \frac{(137.036*.511)}{\frac{1}{3}*\frac{2}{3}(1+.00457)} \right) \mathrm{Mev/c^2}$$

$$= 939.624 \ \mathrm{Mev/c^2}$$

observed 939.565 Mev'c^2

$$M_{Proton} = \left(\frac{(137.036*.511)}{\frac{2}{3}*\frac{1}{3}(1+.00914)} + \frac{(137.036*.511)}{\frac{1}{3}*\frac{2}{3}(1+.00457)} + \frac{(137.036*.511)}{\frac{2}{3}*\frac{1}{3}(1+.00914)} \right) \mathrm{Mev/c^2}$$

$$= 938.204 \ \mathrm{Mev/c^2}$$

observed 938.272 Mev'c^2

Figure A4. Neutron and proton masses, including mass splitting, are accurately predicted by Equation (1) , Dashed lines show where mass equation is applied.

Delta Mass

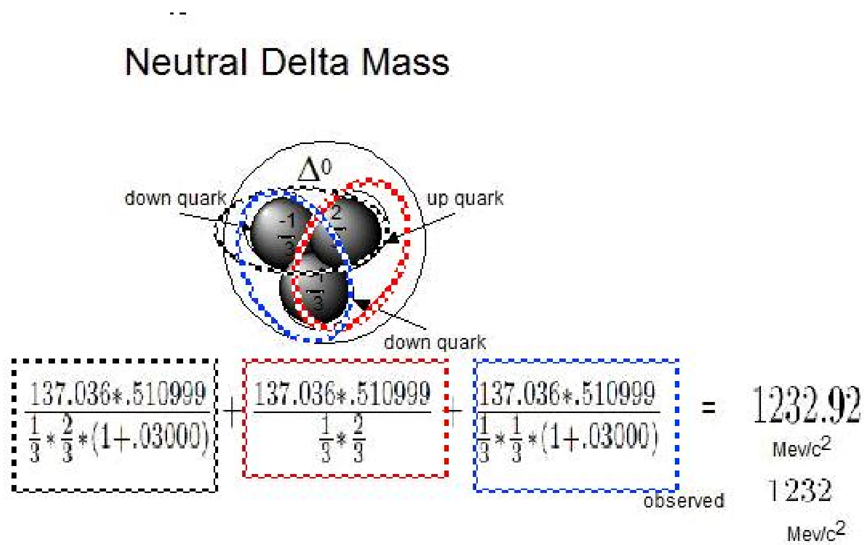


Figure A5. The Delta baryons all have the same mass predicted by Equation (1)Dashed lines show where mass equation is applied. The magnetic corrections, δ_c, are an explanation for the states called "color"so that all the Delta particles, including spin $\frac{3}{2}$, can exist without violating the Pauli exclusion principal. Dashed lines show mass creation interactions.

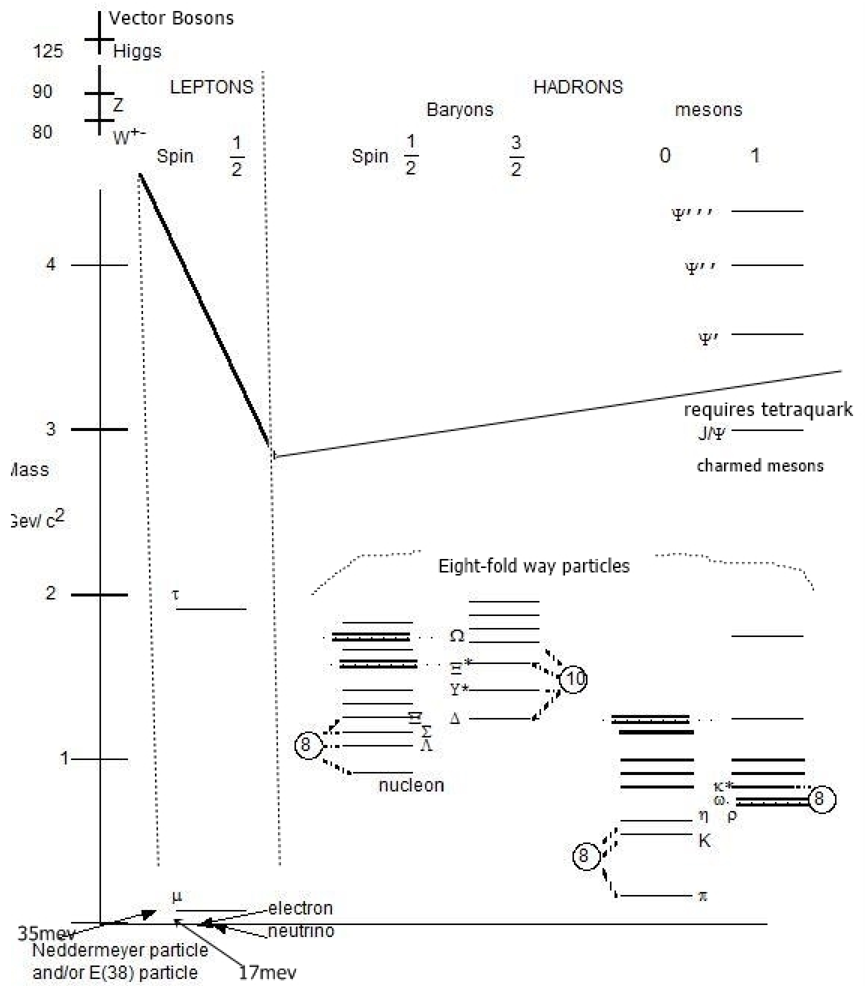


Figure A6.The lowest mass eight-fold-way particles in each column have their masses explained by formula (1) The above diagrams particle masses explained by generalized formula are below the two diagonal lines and near ordinate axis. The mass formula Eq (6) i.e. $M = \frac{\sqrt{2^{f^2}} m_e}{\alpha |q_s||q_t|(1 \pm \delta_c)}$ *explains the strange, the Tau,* $\top$*,* $W^{\pm}$*and* Z^0*with f=2, there also, for the "Higgs", should be a factor of* $\sqrt{N}$*where N is a positive integer to account for resonances.*

$M_{\top au} = \frac{\sqrt{2^{2^2}} m_e}{\alpha |q_{we}||q_{uq}|(1+.00457)} + \frac{\sqrt{2^{0^2}} m_e}{\alpha |q_e||q_{uq}|}$, $M_{W^{\pm}} = \frac{\sqrt{2^{2^2}} m_e}{\alpha |q_{we}||q_{wv}|}$,

$M_{Z^0} = \frac{\sqrt{2^{2^2}} m_e}{\alpha |q_{wv}||q_{wv}|}$, $M_{Higgs} = \frac{\sqrt{2}\sqrt{2^{2^2}} m_e}{\alpha |q_{wv}||q_{wv}|}$, $M_{E38} = \frac{m_e}{\alpha |q_{\Delta^{++}}||q_e|}$,[31][32][33]

$M_{17Mev} = \frac{m_e}{\alpha |q_{\Delta^{++}}||q_{\Delta^{++}}|}$[34]

Apendix B “Eight-Fold-Way-Particles” Mass Calculation Charts and Others

In order to demonstrate that the formula for calculating the Muon mass works for most of the known particles, Charts with the calculations, which also assumes the quark model, observed and calculated masses are presented.

Leptons, Weak “messinger” Bosons, Higgs and possible Dark matter/WIMPs: The E(38)[32][33] and 17mev Boson[34].

The known Leptons, Muon and Tau are presented along with the Weinberg-Salam “messinger “particles, $W^{\pm}$and Z^0 and the so-called “Higgs” boson. Furthermore the existence of charge $+2$ particles (such as Δ^{++}) suggest 2 very light particles exist. They have been claimed have to have been observed. They are the E(38)[31][32][33] and 17Mev Boson[34]. These particles are neutral and if one or both have very long lifetimes, could be a constituent of Dark Matter.

Leptons/other	observed $\frac{Mev}{C^2}$	mass formulae $\frac{Mev}{C^2}$	$\frac{Mev}{C^2}$	%
muon; $\mu^{\pm}$ [a]	105.6583668	$\frac{137.036 * .510999}{\frac{2}{3} * 1} + .510999$	105.549	0.1%
Tau; τ [b]	1776.82	$\frac{137.036 * .510999}{(\frac{2}{3} * \frac{1}{16}) * (1 + .00457)} + \frac{137.036 * .510999}{(\frac{2}{3} * 1)}$	1777.99	0.0066%
W [c]	80385	$\frac{\frac{9}{8} * 137.036 * .510999}{\frac{1}{16} * \frac{1}{16} * \frac{1}{\sqrt{16}}} =$	80669.2	0.35%
Z [d]	91187.6	$\frac{\frac{9}{8} * \frac{9}{8} * 137.036 * .510999}{\frac{1}{16} * \frac{1}{16} * \frac{1}{\sqrt{16}}}$	90752.9	0.48%
Higgs [e]	125000-127000	$\frac{\sqrt{2} * \frac{9}{8} * \frac{9}{8} * 137.036 * .510999}{\frac{1}{16} * \frac{1}{16} * \frac{1}{\sqrt{16}}(1 + .03000)}$ to $\frac{\sqrt{2} * \frac{9}{8} * \frac{9}{8} * 137.036 * .510999}{\frac{1}{16} * \frac{1}{16} * \frac{1}{\sqrt{16}}}$	124606-128344	0.32%-1.1%
E(38) [g]	38 ± 3	$\frac{137.036 * .510999}{2 * 1}$	35	0%-7.8%
Mev 17 boson	17Mev	$\frac{137.036 * .510999}{2 * 2}$	17.5	?

Figure B1. Leptons, Intermediate Vector Bosons, Higgs, E38 , and 17 Mev Boson.

Pseudo-scalar mesons

$\pi^{\pm}$ [i]	139.570	$2 * \frac{137.036 * .510999}{1 * 1} - .510999$	139.540	0.02%
π^{0} [j]	134.976	$2 * \frac{137.036 * .510999}{1 * (1 + .03000)} - (2 * .510999)$	134.979	0.002%
η [k]	547.853	$\sqrt{\left(\frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3} * (1 - .00456)}\right)^2 + \left(\frac{\sqrt{2} * 137.036 * .510999}{\frac{2}{3} * \frac{1}{3} * (1 - .00456)}\right)^2}$	548.293	0.008%
η' [l]	957.78	$\sqrt{\left(\frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3} * (1 - .00914)}\right)^2 + \left(\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 - .00914)}\right)^2}$	954.061	0.39%
$K^{\pm}$ [m]	493.677	$\sqrt{\left(\frac{\sqrt{2^f = 2^1} * 137.036 * .510999}{\frac{2}{3} * \frac{2}{3}(1 + .00914)}\right)^2 + \left(\frac{\sqrt{2^f = 2^1} * 137.036 * .510999}{\frac{2}{3} * \frac{1}{3}(1 + .00914)}\right)^2}$	493.728	0.01%
K_L^{0} [n]	497.614	$\sqrt{\left(\frac{\sqrt{n = 2} * 137.036 * .510999}{\frac{2}{3} * \frac{2}{3}}\right)^2 + \left(\frac{\sqrt{2^f = 2^1} * 137.036 * .510999}{\frac{2}{3} * \frac{1}{3}}\right)^2}$	498.239	0.125%
K_S^{0} [o]	497.614	$\sqrt{\left(\frac{\sqrt{n = 2} * 137.036 * .510999}{\frac{2}{3} * \frac{2}{3}}\right)^2 + \left(\frac{\sqrt{n = 2} * 137.036 * .510999}{\frac{2}{3} * \frac{1}{3}}\right)^2}$	498.239	0.125%

Figure B2 Pseudo-scalar mesons.

vector mesons

	observed $\frac{Mev}{C^2}$	Vector meson formulae $\frac{Mev}{C^2}$	calculated $\frac{Mev}{C^2}$	%
$\rho^{\pm}$ [p]	775.11	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}} + (2 * \frac{137.036 * .51099}{1 * 1 * (1 - .03000)})$	774.610	0.064%
ρ^{0} [q]	775.49	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}} + (2 * \frac{137.036 * .510999}{1 * 1 * (1 - .03000)})$	774.610	0.11%
ω [r]	782.65	$\frac{137.036 * .510999}{\frac{2}{3} * \frac{2}{3} * (1 + .03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}}$	783.197	0.07%
ϕ [s]	1019.445	$\sqrt{\left(\frac{\sqrt{2} * 137.036 * .510999}{\frac{2}{3} * \frac{1}{3} * (1 - .03000)}\right)^2 + \left(\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 - .03000)}\right)^2}$	1027.300	0.77%
$K*^{\pm}$ [t]	891.66	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{1}{3}}$	891.278	0.043%
$K*^{0}$ [u]	895.94	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{1}{3}(1 - .00457)}$	895.090	0.095%

Figure B3 Vector Mesons

Spin $\frac{1}{2}$ Baryons

	Observed $\frac{Mev}{C^2}$	spin $\frac{1}{2}$ Baryons mass formulae $\frac{Mev}{C^2}$	calculated $\frac{Mev}{C^2}$	%
$p^{+\ v}$	938.272	$\frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3}(1+.00914)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1+.00457)} + \frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3}(1+.00914)}$	938.204	0.007%
$n^{0\ w}$	939.565	$\frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3}(1+.00457)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1+.00914)} + \frac{137.036 * .510999}{\frac{2}{3} * \frac{1}{3}(1+.00457)}$	939.624	0.0062%
$\Lambda^{0\ x}$	1115.63	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1-.03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1-.03000)} + \frac{\sqrt{2}\,137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1-.03000)}$	1109.14	0.6%
$\Sigma^{+\ y}$	1189.37	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00457)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.03000)}$	1188.53	0.07%
$\Sigma^{0\ z}$	1192.64	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.03000)}$	1193.41	0.065%
$\Sigma^{-\ aa}$	1197.44	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00914)}$	1197.93	0.041%
$\Xi^{0\ bb}$	1314	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1+.03000)}$	1315.87	0.14%

Figure B4. Spin $\frac{1}{2}$ Baryons

Spin $\frac{3}{2}$ Baryons

Particle	Observed mass[16]	spin 3/2 Baryons Formula	Calculated mass	% diff
Δ^{++} *dd*	1232	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .03000)}$	1232.92	0.075%
Δ^{+} *ee*	1232	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .03000)}$	1232.92	0.075%
Δ^{0} *ff*	1232	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .03000)}$	1232.92	0.075%
Δ^{-} *gg*	1232	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .03000)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .03000)}$	1232.92	0.075%
$\Sigma *^{+}$ *hh*	1382.8	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .00914)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}}$	1382.42	0.027%
$\Sigma *^{0}$ *ii*	1383.7	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3} * (1 + .00914)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3} * (1 + .00457)} + \frac{\sqrt{2} * 137.036 * .511}{\frac{1}{3} * \frac{2}{3} * (1 + .00457)}$	1383.23	0.034%
$\Sigma *^{-}$ *jj*	1387.2	$\frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 + .00914)}$	1386.94	0.019%
$\Xi *^{0}$ *kk*	1531.80	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .00914)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}(1 - .00457)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .00914)}$	1532.38	0.038%
$\Xi *^{-}$ *ll*	1535.0	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .00914)} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{1}{3}(1 - .00914)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .00914)}$	1535.53	0.038%
Ω^{-} *mm*	1672.45	$\frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .03000)} + \frac{\sqrt{2} * 137.036 * .510999}{\frac{1}{3} * \frac{1}{3}} + \frac{137.036 * .510999}{\frac{1}{3} * \frac{2}{3}(1 - .03000)}$	1675.55	0.19%

Figure B5. Spin $\frac{3}{2}$ *Baryons.*

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