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Mendeleev-like Tables of Elementary Particles

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Abstract

The Vir Theory of Elementary Particles provides a formula for the relationship between mass and spin. Using this formula the masses of over 200 particles were calculated with such accuracy that the errors from the actual masses are entirely attributable to the mass measurement errors. The particles come from 16 families including the lightest family N and the heaviest family χY. For each family of particles considered there is one or more Mendeleev-like table where the columns have increasing spin and the rows increasing mass, in such a way that the diagonal cells have the same predicted mass. The empty cells should in future be filled by new particles.

Keywords: elementary particles, phenomenology, mass calculations, spin, Mendeleev, tables

1. Introduction

As far as we know all matter is made up from three elementary particles: proton, neutron and electron. However there are over 200 other elementary particles found in the cosmic rays and collisions in particle accelerators that are too short-lived to be components of any chemical elements. They have very few fundamental properties, namely: mass, spin and electric charge. Since the discovery of these short-lived particles attempts have been made to find the relationship between mass and spin, for this would shed the light also on the nature of proton and neutron. However, all efforts thus far have failed.

In the early 1960s three quarks u, d and s were postulated to be the components of elementary particles and were assigned masses in such a way that the masses of the known spin ½ particles p, Λ, Σ, Ξ agreed with the sum of their constituent quarks with the precision of 0.1% - 6% error. However, using the same quarks the masses of spin 1 particles K, π, ρ, ω disagreed by 20% - 60% error.

Later a formula was found that provided the correction to the particle mass using the reciprocal quark masses which greatly improved the accuracy to about 1%. However, as more particles were discovered some of them had the same constituent quarks but different masses and thus the mass correction formulas became inadequate.

To avoid this problem an assumption was made that quarks have not only electric charges but also similar charges with much stronger forces. Instead of + and – charge there were three varieties and they were usually referred to as red, green and blue. This area of research was named Quantum Chromodynamics (QCD) [1].

With the discovery of more and more particles QCD also ran into problems. The current belief is that quarks have much smaller masses than originally thought and the masses of particles are mostly due to the kinetic energy of quarks orbiting inside particles. All that can be said about mass and spin is that in a given family of particles the mass of the lightest particle in each spin increases with the spin, due to the increasing orbital energy of quarks required for increasing particle spin.

The Vir Theory of Elementary Particles [2] provides a formula for the relationship between mass and spin. Using this formula the masses of 209 particles were calculated with such accuracy that the errors from the actual masses are entirely attributable to the mass measurement errors. Since the formula does not yet include the effect of the electric charges on mass, as for example in proton/neutron or Σ^-/ Σ^0/ Σ^+, we use on such occasions the average mass based on the extreme minimum and maximum mass limits.

The formula for the mass *m* provided by the Vir Theory of Elementary Particles is as follows

$$m = b(2s + 2c - 1)^{\beta} \tag{1.1}$$

where *s* is the particle spin and *c* is the number of particle parts with spin ½ that rotate in the opposite direction to the particle spin, i.e. integers 0, 1, 2, 3, etc. The parameters *b* and β are obtained by a purpose-written computer programme so as to give the smallest possible sum of the squared errors.

For each family of particles considered there is one or more Mendeleev-like table with different parameters *b* and β. The columns have increasing *s* and the rows increasing *c*. The variables *s* and *c* describe the particle structure, in analogy to Mendeleev tables describing the atomic structure. The implication of this structure is that an empty table cell should in future be filled by a new particle. We see from the formula above that for the pairs (*s*, *c*) with the same sum *s* + *c* the mass is the same. Thus the cells arranged diagonally in the table have the same predicted mass.

The following 16 particle families are included: N, Δ, Λ, Σ, Ξ, aρ, fω, K, Λc, Σc, Ξc, D, Ds, X, χψ, χY. They include the lightest family N and the heaviest family χY. Out of all particles involved that have more than one mass measurement with the latest measurement taken within the last 12 years only 12 particles do not appear in the tables, possibly because they have originally been misplaced.

Each table is determined by the constants *b* and β which may seem like a lot of “arbitrary” constants. However the constant *b* is the predicted mass of the lightest particle in the family with spin 1, hence there is nothing arbitrary about it. It turns out that the constants β are not arbitrary either because when we multiply *b* by β we get approximately the constant $\gamma \approx 0.3868$ GeV. This constant was determined by regression with the correlation factor $R^2 = 0.9995$ and the probability that using the given data this may happen at random $P = 10^{-55}$. Hence there is only one empirically derived constant, which may well reflect a deep property of the relativistic ether.

From the mass formula we can easily obtain a formula for $m^{1/\beta}$. This is useful for plotting graphs because $m^{1/\beta}$ is linear in *s* for a given value of *c*. The slope is the same for all values of *c* so that a graph consists of parallel lines intersecting the spin axis at ½ and at one spin intervals extending into negative values. A horizontal line on such a graph intersects all sloping parallel lines, showing that particles of all spin may have the same mass. Similarly, a vertical line going through a point of positive spin *s* also intersects sloping parallel lines, showing that particles of a given spin may have several masses.

Sufficient information to understand how formula (1.1) comes about is provided in the next section, here is just a very brief outline. Using the Euler equation for the motion of rotating bodies it is found that a symmetric solid of rotation which is not perfectly circular but slightly elliptical precesses in such a way that the axis of spin describes a circular but sinusoidal trajectory. After one rotation it returns to its initial state only if the ratio of its moments of inertia Ix/Iz is an integer or half integer.

It has been proven mathematically using the Euler-Lagrange equations that the symmetric concave spinning top with the minimum moment of inertia has the shape of twin vortices with the common spin axis connected at the large ends. Vir theory assumes that hadrons are such vortices in relativistic ether. Such vortices self-destruct on completion of one revolution, unless the start and end of the circular wave are in phase. Thus only vortices for which Ix/Iz is an integer or half integer survive. The lowest possible ratio of Ix/Iz is for a planar disk with Ix/Iz = ½ and this leads to the spin of such vortices being quantised. Working out the integrals for the mass and the moments of inertia leads directly to formula (1.1).

The fact that vortices give least resistance to spinning gives Vir theory the same solid mathematical foundation as have all theories founded on the principle of least effort, i.e. least action. These theories include Optics, Newtonian Mechanics, Special Relativity, General Relativity and Quantum Mechanics.

2. Theoretical background

The Vir Theory of Elementary Particles is described in detail in paper [2]. Here we will outline only those features that are relevant to this paper. It has been proven mathematically using the Euler-Lagrange equations that the symmetric concave spinning top with the minimum moment of inertia, i.e. with the least resistance to spinning, has the shape of a solid of rotation generated by the profile function r(z) called Vir [3].

$$r(z) = a\left(\frac{a}{|z|}\right)^{\alpha} \qquad \text{where} \qquad \alpha \succ 0 \qquad a \succ 0 \tag{2.1}$$

The parameter a gives the size, if $z = a$ then $r = a$ and vice versa, while the parameter α gives the shape. It has also been shown experimentally [4] that water and air vortices have the Vir shape with observed values of $\alpha = [0.6, 2.5]$.

Vir Theory of Elementary Particles assumes that particles are symmetric twin vortices in the relativistic ether, i.e. consisting of two vortices spinning about a common axis that are joined at the large ends. For the purpose of calculating the volume, mass and the moments of inertia we can treat a particle as a symmetric solid of revolution generated by the profile function r(z) in (2.1).

Since for symmetric twin vortices $r(z) = r(-z)$ it is sufficient to consider $r(z)$ only on the interval $[0, Z]$ where Z is the height of a vortex half. For a profile curve $r(z)$ the expressions for mass m and the moments of inertia around axes z and x, i.e. Iz and Ix are

$$m = 2\rho\pi\int_0^Z r(z)^2 dz \tag{2.2}$$

$$I_z = \rho\pi\int_0^Z r(z)^4 dz \tag{2.3}$$

$$I_x = \rho\pi\int_0^Z \tfrac{1}{2}r(z)^4 + 2r(z)^2 z^2 dz \tag{2.4}$$

Since the shape of the vortices is the solid of rotation around axis z generated by the profile function $r(z)$ the moment of inertia around axis y is the same as around axis x. For a Vir with an infinite radius $r(z)$ at $z = 0$ the evaluation of the above integrals gives us

$$m = 2\rho\pi\frac{a^{2+2\alpha}}{1-2\alpha}Z^{1-2\alpha} \qquad \alpha < ½ \tag{2.5}$$

$$I_z = \rho\pi\frac{a^{4+4\alpha}}{1-4\alpha}Z^{1-4\alpha} \qquad \alpha < ¼ \tag{2.6}$$

$$I_x = \rho\pi\frac{a^{2+2\alpha}}{3-2\alpha}Z^{3-2\alpha} \qquad \alpha < 3/2 \tag{2.7}$$

Using the formulas above we find the following formula for mass m

$$m = b(2\sigma - 1)^{\beta} \tag{2.8}$$

where σ is the particle spin in the units of ħ, i.e. an integer or half integer, 1/2, 1, 3/2, 2, 5/2, etc.

$$\sigma = \frac{Ix}{Iz} \tag{2.9}$$

and $$\beta = \frac{1-2\alpha}{2+2\alpha} \qquad 1/2 > \beta > 1/5 \tag{2.10}$$

where $$\alpha = \frac{1-2\beta}{2+2\beta} \qquad 0 < \alpha < 1/4 \tag{2.11}$$

$$b = 2\rho\pi a^3 \frac{1}{1-2\alpha}\left(\frac{1}{4}\frac{3-2\alpha}{1-4\alpha}\right)^{\beta} \tag{2.12}$$

When we know the parameters b and β we can find the corresponding parameters a and α

$$a = \left(\frac{3b}{2\rho\pi}\frac{\beta}{1+\beta}\right)^{\frac{1}{3}}\left(4\frac{5\beta-1}{5\beta+2}\right)^{\frac{\beta}{3}} \tag{2.13}$$

The relation (2.9) between Ix, Iz and σ comes about by considering a particle as a spinning top and applying to it the Euler equations of motion for rotating bodies. A spinning top that is not perfectly circular but slightly elliptical, like hurricanes, precesses in such a way that the axis of spin describes a circular but sinusoidal trajectory. Such a spinning top in air or water generates a circular wave that on completion of one revolution is in phase only if σ is an integer or half integer. Only under these conditions the wave does not destroy itself. Furthermore, the smallest possible value of σ is ½ which corresponds to a planar disk, which we can roughly imagine as a paper disk spinning on a needle though its centre, or as the Saturn ring.

For a solid spinning top with a known moment of inertia Iz and angular velocity ω the angular momentum about axis z is simply Iz times ω. However, for a vortex there is no angular velocity, different parts of a vortex rotate at different angular velocity. Thus Vir theory postulates that the angular momentum of a particle, i.e. its spin, is σ in (2.9) measured in the units of ħ.

To complete the outline of the theory we will need one more formula, namely the dependence of the height (depth) Z on σ

$$Z = a\left(\frac{3-2\alpha}{1-4\alpha}\frac{2\sigma-1}{4}\right)^{\frac{1}{2+2\alpha}} \tag{2.14}$$

Since α and σ are dimensionless quantities we have the height in the units of the parameter a.

The mass formula (2.8) can be modified to take into account the structure of particles. Figures 1 and 2 show the structure of a baryon and a meson, the baryon has $\sigma = 2.5$ and the meson has $\sigma = 3$. The parameter σ is the spin of a particle when the entire particle rotates in the same direction. The horizontal lines in figure 1 show the heights for a baryon with $\sigma = 0.5$, 1.5 and 2.5. The line through the centre is the baryon disk with spin 0.5 but (virtually) no mass, which on its own cannot constitute a hadron. The horizontal lines in figure 2 show the heights for a meson with $\sigma = 1$, 2 and 3.

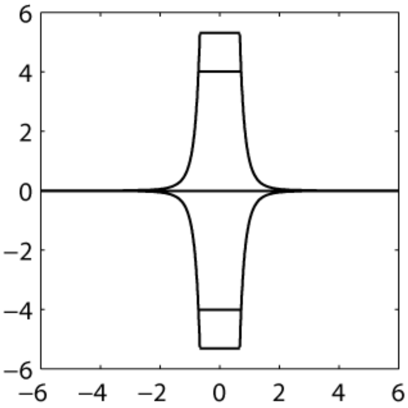

FIGURE 1. Baryon

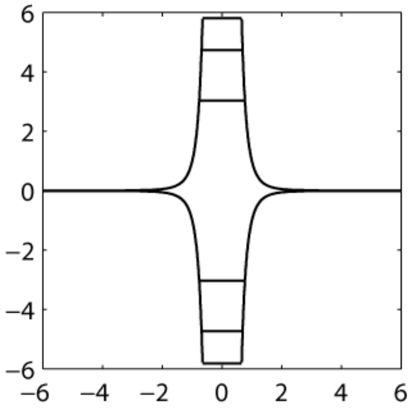

FIGURE 2. Meson

To obtain a baryon with spin 0.5 we assume that it has the shape, height and mass of $\sigma = 1.5$, but the disk rotates in the opposite direction. This is because in the absence of the disk the spin would be reduced by 0.5 and with the disk rotating in the opposite direction the spin is reduced by another 0.5. We find a similar phenomenon in hurricanes where the visible part (warm air) rises up from the ground (or sea) rotating anticlockwise, but when it ascends above the hurricane it suddenly turns and rotates clockwise. We can extend this idea, by rotating not only the disk but the adjacent parts in the opposite direction to the end parts we can obtain baryons spin 0.5 with the mass corresponding to $\sigma = 2.5$, 3.5, etc. This way for a given baryon σ we can obtain also any half integer spin s smaller than σ.

Similarly we can obtain a meson spin 0 starting with $\sigma = 2$ and have the ends rotating in the opposite direction to the middle section. We can do this starting from any even σ. However, when σ is odd then we can do it only if we are prepared to accept asymmetrical particles, where the top and bottom may have a different rotation pattern. For example the top rotating in the opposite direction to the bottom. More generally, if we wish to keep particles symmetrical we can obtain an even spin particle only from an even σ and odd spin particles only from an odd σ.

The horizontal lines in figures 1 and 2 separate the particles into notional "slices" with spin ½. The slices that rotate in the opposite direction to the particle with spin s are called "contras" and the number of contras is denoted by the variable c. The relationship between σ, s and c is as follows

$$s = \sigma - c \qquad \text{i.e.} \qquad \sigma = s + c \tag{2.15}$$

Substituting this into the mass formula (2.8) we obtain

$$m = b(2s + 2c - 1)^{\beta} \tag{2.16}$$

The formula above allows one family of particles to have particles with the same mass but different spin and vice-versa, for a given spin there may be particles with different masses.

3. Particles data and error processing

Comprehensive data about elementary particles are kept by the international organisation “Particles Data Group” (PDG) on a website hosted by the University of California [5]. Each particle for which credible data have been published has its own section in the “Particle Listings”. Particles for which more accurate information has been compiled, usually including: “best mass estimate”, “minimum mass”, “maximum mass”, “spin” and “parity” appear also in the “Particles Summary”. The mass estimates are based on the published measurements that are included in the Particles Listings. The values of the best mass, min mass and max mass are not derived by purely statistical means, but also other considerations such as the overall consistency. For example, the values for Σ particles take into consideration the values of Λ particles that appear together in many reactions. The net result of such adjustments is that the best mass may not be the average of the min and max limits, hence the limits cannot be interpreted as the statistical standard deviation. In some extreme cases a mass limit coincides with the best mass, as for example in the case of Λ(1830) where the best mass = max mass = 1830MeV.

In this paper, when the predicted mass falls outside the PDG limits we wish to estimate the seriousness of this departure. To do so we define the “relative prediction error” (RPE) that is the ratio of two distances from the best mass, namely the distance of the predicted value divided by the distance of the minimum or the maximum mass, as appropriate. In the example given above this can lead to an infinite RPE. In cases where the mass limits are less skewed, RPE is finite but may be equally unacceptable. Therefore when the predicted mass is outside the PDG limits we compute the standard deviation using the measurements in the PDG Listings. The computation method [6] gives the standard deviation that is usually smaller because by convention the error limits are those of the standard error, which is smaller than the standard deviation by the factor $1/\sqrt{N}$, where N is the number of measurements. We use the same method also for the particles for which there are no PDG limits, which applies to a vast majority of the particles not included in PDG Summary.

The PDG website is thoroughly updated every even year and partially updated every odd year. Most of the changes are small enough not to make a significant difference to our results. However, occasionally there are some very significant changes. For example for Λ(1405) the best mass was 1407.0 MeV in 2004, 1406.0 in 2008, and 1405.1 in 2015, meanwhile the max mass decreased to 1406.4, which is smaller than the best mass in 2004! This paper uses the data updated in 2015, which being only a partial update may not always be most consistent. Therefore when we encounter RPE > 1 we first try the data from 2008 before resorting to computing the standard deviation.

As a rule unflavoured and strange hadrons with the mass greater or close to 3000 MeV appear only in PDG Listings without any limits, spin, parity and our computation usually results in an extremely large standard deviation, giving RPE < 1 for an unacceptably large range of values. There are seven such particles which due to the lack of reliable data will be excluded from any further consideration.

The theory on which the predicted mass is based does not yet consider the effect of the electric charge on the mass. Thus for particles that involve more than one charge versions we use the extreme min and max mass limits and take the average as the best mass estimate. Thus for example proton and neutron are combined into nucleon N{939} and Σ^-, Σ^0, Σ^+ into Σ{1193}. This gives the relative min, max ±error 0.069% for N and 0.343% for Σ.

The predicted masses for a PDG family of particles depends entirely on two parameters b and β in formula (2.14). We use a purpose written MATLAB programme to obtain these parameters. Essentially, the programme minimises the sum of the squared RPEs, i.e. it obtains the best fit to the actual values.

4. Table of baryons N1

On the graphs below the best PDG mass is marked by a blue circle for the positive parity and a red diamond for the negative parity. The min and max masses are marked by + signs. The headings give particle names and prediction errors, i.e. the ratios of the distances from the best mass to the prediction line and to the PDG minimum or maximum. The bottom prediction line with the intercept -0.5 corresponds to the second row of the table. The higher lines correspond to the lower rows. Thus N(1650) with spin 0.5 on the top line has error +0.89, it is positive since the prediction line is above the particle.

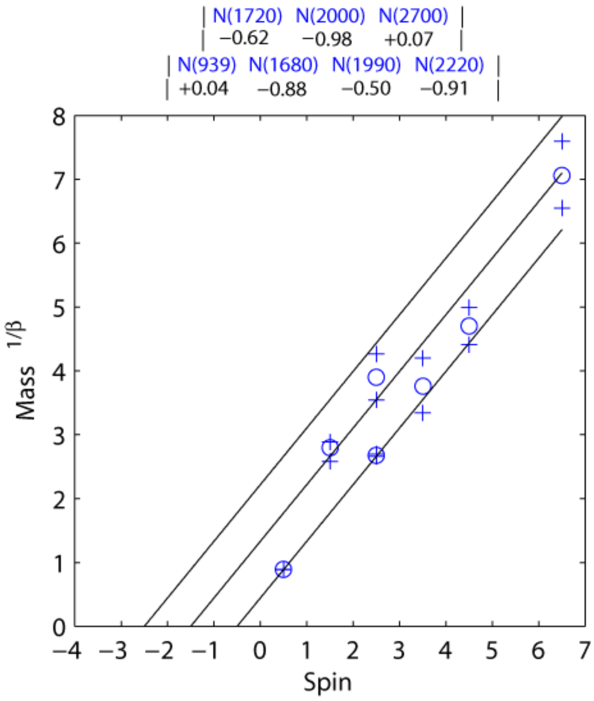

FIGURE 3. Positive parity N1

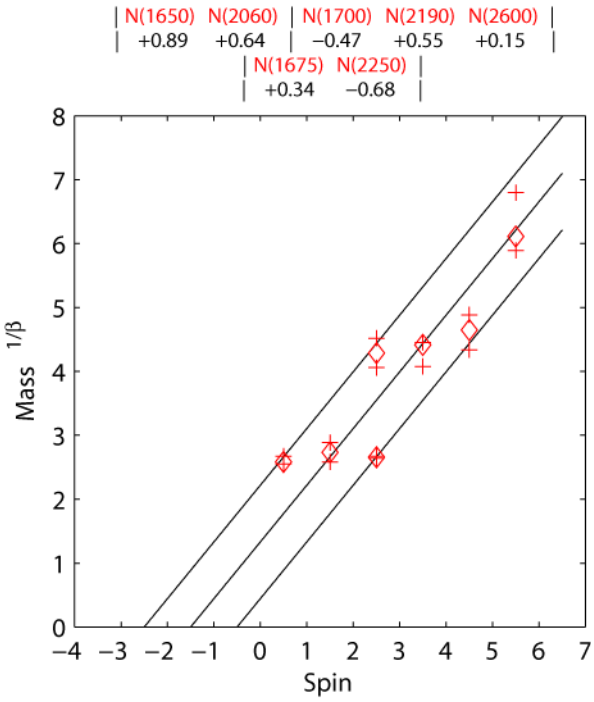

FIGURE 4. Negative parity N1

Size b = 0.651		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.528	
Contras	0	zero mass								+ -	Parity
	1	N{939}		N(1680) N(1675)	N(1990)	N(2220) N(2250)				+ -	
	2		N(1720) N(1700)	N(2000)	N(2190)		N(2600)	N(2700)		+ -	
	3	N(1650)		N(2060)						+ -	
	4								unlikely	+ -	

TABLE 1. Mendeleev-like table of baryons N1

Summary limits re-computed: N(1680), N(2220)
Listings limits re-computed:
Listings limits 1st-computed: N(1990), N(2060), N(2700)

5. Table of baryons N2

Not all nucleon particles fit the predicted mass graph on the previous page. In fact almost an equal number fit the predicted mass on the graph below, with different b and β. The heavy particles with high spin N(2700) and N(2600) have considerable measurement errors spanning two prediction lines, which may indicate that the measurements used by PDG may involve more than one particle.

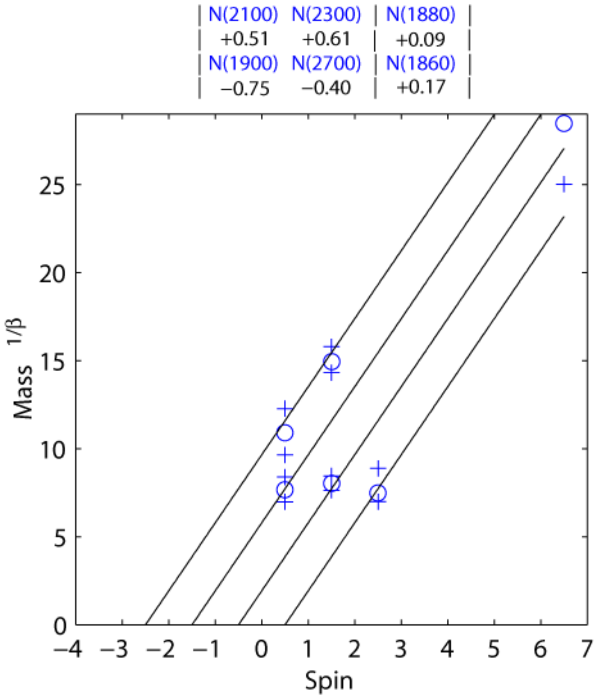

FIGURE 5. Positive parity N2

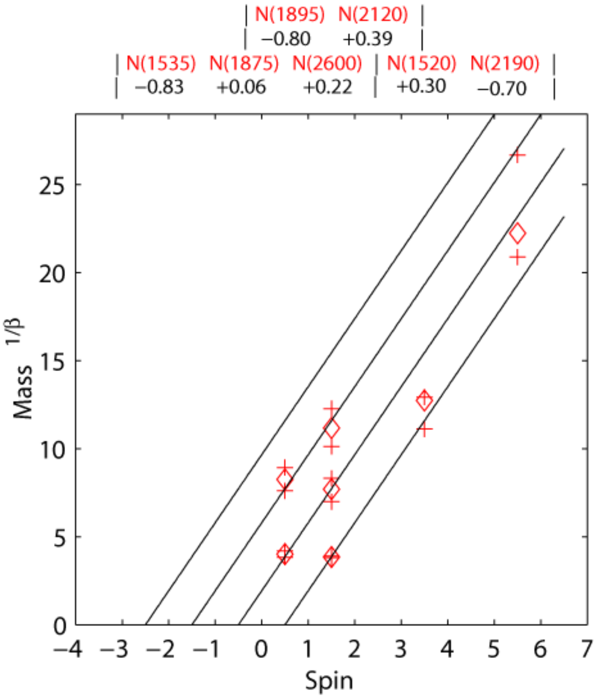

FIGURE 6. Negative parity N2

Size b = 1.220		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.308	
Contras	0	zero mass	N(1520)	N(1860)	N(2190)					+ -	Parity
	1	N(1535)	N(1900) N(1875)				N(2600)	N(2700)		+ -	
	2	N(1880) N(1895)	N(2120)							+ -	
	3	N(2100)	N(2300)							+ -	
	4								unlikely	+ -	

TABLE 2. Mendeleev-like table of baryons N2

Summary limits re-computed: N(1535)
Listings limits re-computed:
Listings limits 1st-computed: N(1880), N(1895), N(2100), N(2120), N(2700)

Summary particles missing: N(1440), N(1710)
Listings particles missing: N(2040), N(2570)

6. Table of baryons Δ1

The prediction lines correspond to the rows in the table. The diagonals in the table rising from left to right correspond to the notional horizontal lines in the diagrams. Each such line corresponds to a fixed mass value. For example, the diagonal cells containing particles Δ(1910), Δ(1900), Δ(1920), Δ(1905), Δ(1930), Δ(1950) are all on one horizontal graph line that runs between their minima and maxima, except for Δ(1905), that has RPE = +1.1.

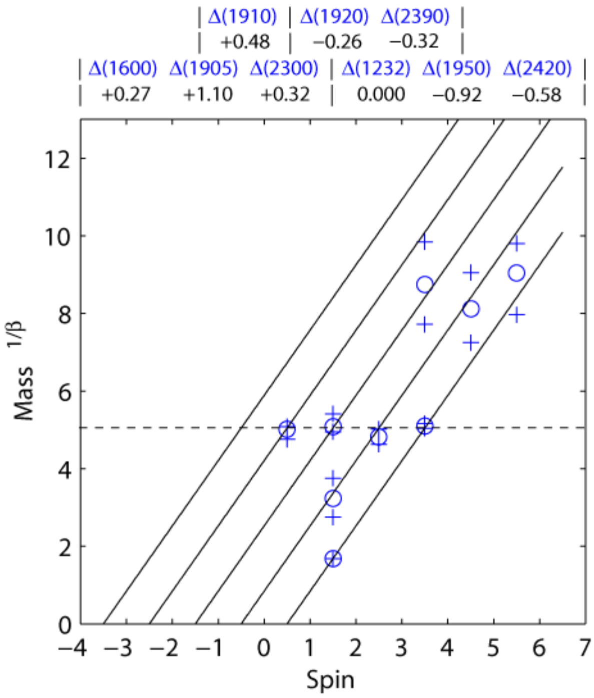

FIGURE 7. Positive parity Δ1

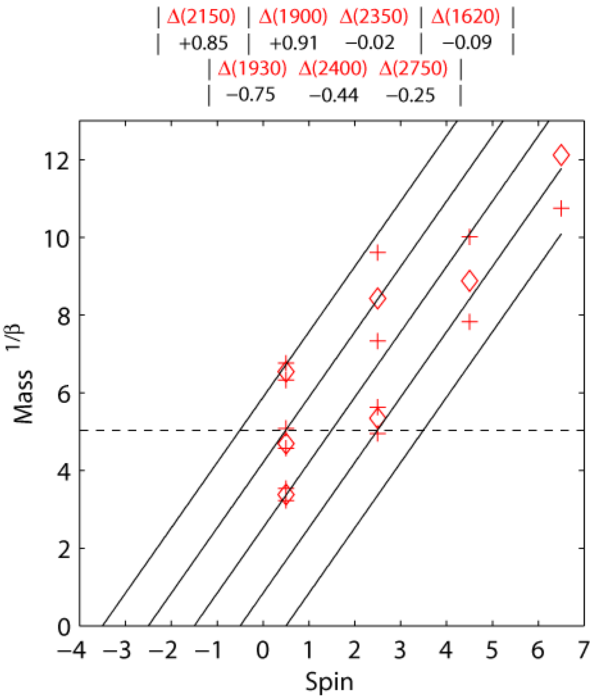

FIGURE 8. Negative parity Δ1

Size b = 0.933 Contrast	Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.401 Parity
0		**Δ{1232}**		**Δ(1950)**		**Δ(2420)**			+ -
1		**Δ(1600)**	**Δ(1905)** **Δ(1930)**		**Δ(2300)** **Δ(2400)**		**Δ(2750)**		+ -
2	**Δ(1620)**	**Δ(1920)**		**Δ(2390)**					+ -
3	**Δ(1910)** **Δ(1900)**		**Δ(2350)**						+ -
4	**Δ(2150)**								+ -

TABLE 3. Mendeleev-like table of baryons Δ1

Summary limits re-computed: Δ(1905), Δ(1950)
Listings limits re-computed:
Listings limits 1st-computed: Δ(2150), Δ(2300), Δ(2350), Δ(2390), Δ(2400), Δ(2750)

Summary particles missing: Δ(1700)
Listings particles missing: Δ(1750), Δ(1940), Δ(2000), Δ(2200)

7. Table of strange baryons Λ1

Lambda particles have strangeness = -1, same as sigma particles. They differ mainly because spin 0.5 Λ{1116} is neutral, while spin 0.5 Σ{1193} has three charge varieties. As a result the measurement errors for lambda are of the order of magnitude smaller. This is beyond the accuracy of our model, which at present ignores the effect of the charge on the mass. Therefore for Λ{1116} we use the same relative measurement errors as for Σ{1193}. In Vir theory only neutral particles have inherent parity (left or right handed) and both variety have the same mass. The table below has three such pairs highlighted in thicker border. Λ(2585) is shown in black because PDG has not assign it the parity.

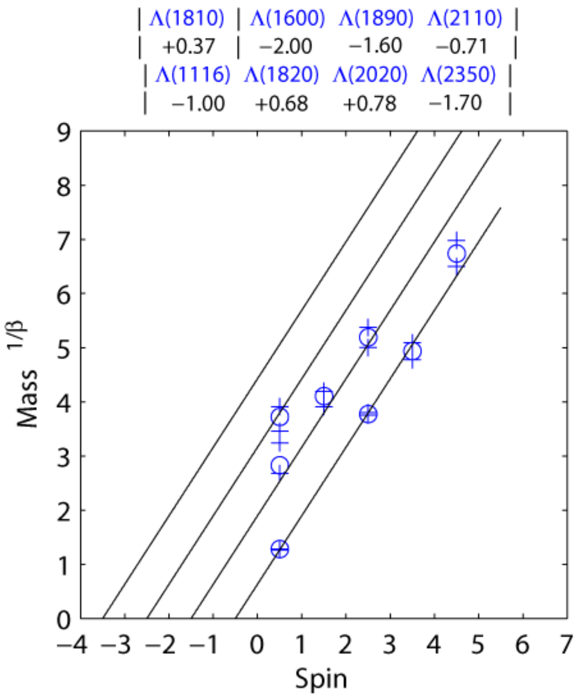

FIGURE 9. Positive parity Λ1

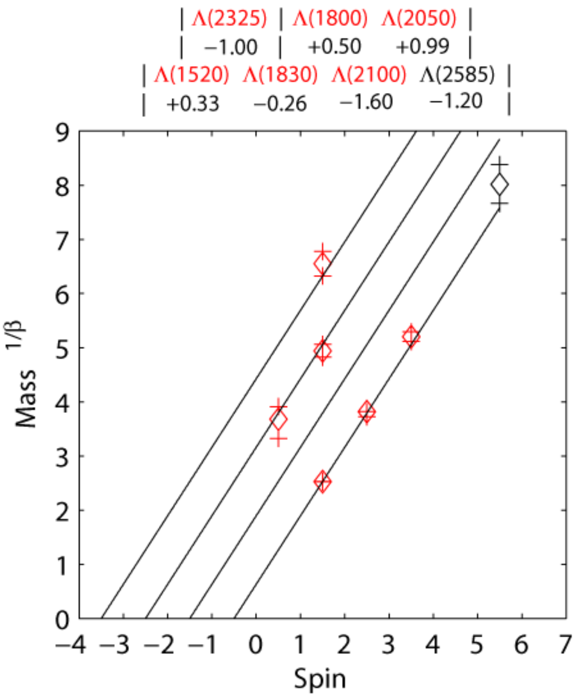

FIGURE 10. Negative parity Λ1

Size b = 0.813		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.451	
Contras	0									+ -	Parity
	1	Λ{1116}	Λ(1520)	Λ(1820) Λ(1830)	Λ(2020) Λ(2100)	Λ(2350)	Λ(2585)			+ -	
	2	Λ(1600)	Λ(1890)	Λ(2110)						+ -	
	3	Λ(1810) Λ(1800)	Λ(2050)							+ -	
	4		Λ(2325)							+ -	

TABLE 4. Mendeleev-like table of strange baryons Λ1

Summary limits re-computed: Λ(1820), Λ(2100), Λ(2110), Λ(2350);
Λ{1116} limits proportional to Σ{1193}.

Listings limits 1st-computed: Λ(2020), Λ(2325), Λ(2585)

8. Table of strange baryons Λ2

As in the case of nucleons not all lambda particles fit the predicted mass graph on the previous page. A much smaller number of particles fit the predicted mass on the graph below, with different *b* and *β*. Particle Λ(2000) is shown in black because PDG has not been able to assign it the parity.

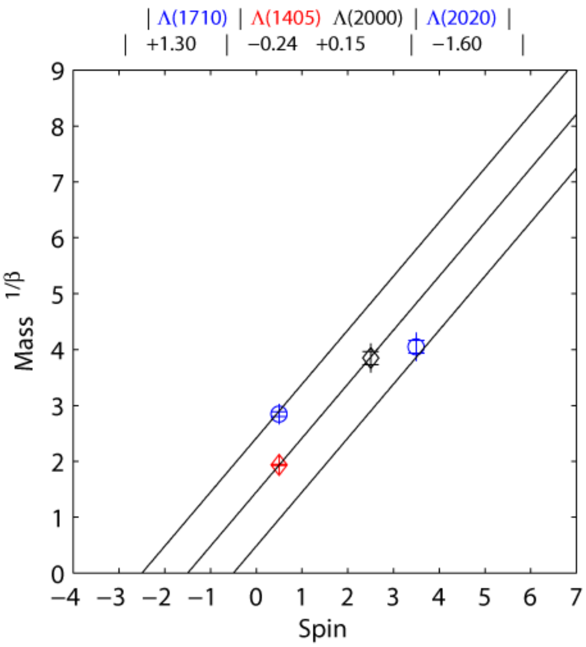

FIGURE 11. Positive and negative parity Λ2

Size		Spin								Shape	
b = 0.688		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	β = 0.515	
Contras	0									+ -	Parity
	1				**Λ(2020)**					+ -	
	2	**Λ(1405)**		**Λ(2000)**						+ -	
	3	**Λ(1710)**								+ -	
	4									+ -	

TABLE 5. Mendeleev-like table of strange baryons Λ2

Summary limits re-computed: Λ(1405) limits proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed: Λ(2000), Λ(2020)

Summary particles missing: Λ(1670), Λ(1690)
Listings particles missing:

9. Table of strange baryons Σ1

Sigma particles have strangeness = -1. This table contains spin 1.5 particle Σ(1385) that played a pivotal role in uncovering the Decuplet pattern which in turn lead to the concept of the strange quark. It has very small measurements errors showing as a single line in figure 12. Particles Σ(2250), Σ(2455) and Σ(2620) are shown in black because PDG has not been able to assign them the parity.

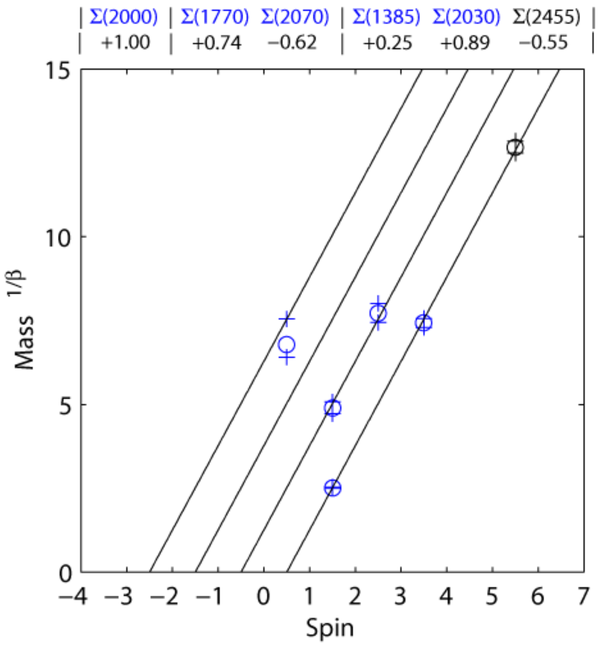

FIGURE 12. Positive parity Σ1

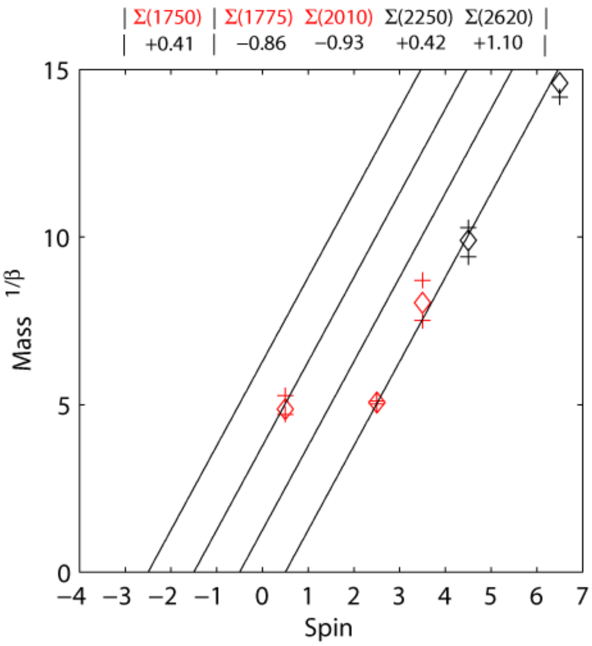

FIGURE 13. Negative parity Σ1

	Size b = 1.080	Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.354	
Contras	0		**Σ(1385)**	**Σ(1775)**	**Σ(2030)** **Σ(2100)**	**Σ(2250)**	**Σ(2455)**	**Σ(2620)**		+ -	Parity
	1		**Σ(1770)**	**Σ(2070)**						+ -	
	2	**Σ(1750)**								+ -	
	3	**Σ(2000)**								+ -	
	4									+ -	

TABLE 6. Mendeleev-like table of strange baryons Σ1

Summary limits re-computed: Σ(2030)
Listings limits re-computed:
Listings limits 1st-computed: Σ(1770), Σ(2000), Σ(2070), Σ(2100), Σ(2455), Σ(2620)

10. Table of strange baryons Σ2

Not all sigma particles fit the table on the previous page. In fact an equal number fit the predicted mass on the table below, with different *b* and *β*. In Vir theory charged particles have no inherent handedness, instead in reactions adjust their spin orientation so as to preserve the total angular momentum. Thus measurement may produce different mass for plus and minus parity, as shown in the table for two such pairs highlighted by thicker borders.

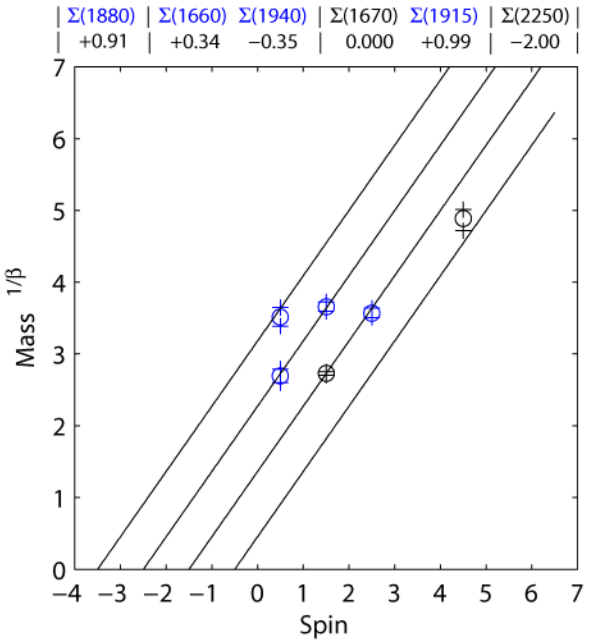

FIGURE 14. Positive parity Σ2

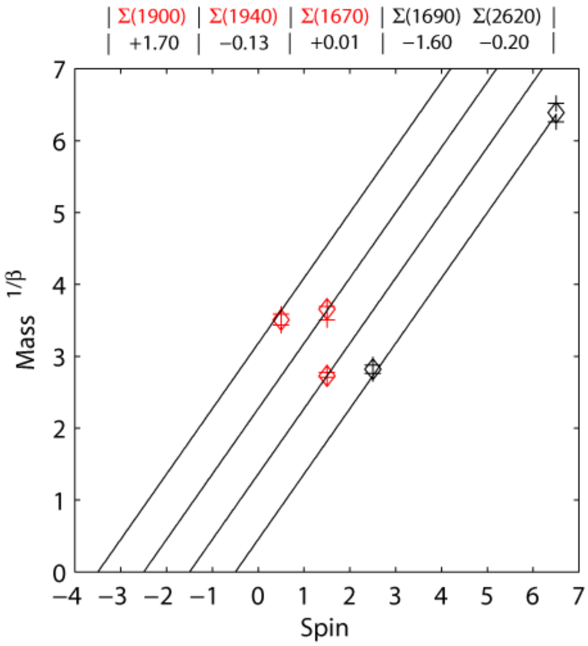

FIGURE 15. Negative parity Σ2

Size b = 0.656		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.520	
Contrast	0									+ -	Parity
	1			**Σ(1690)**		**Σ(2250)**		**Σ(2620)**		+ -	
	2		**Σ(1670)** **Σ(1670)**	**Σ(1915)**						+ -	
	3	**Σ(1660)**	**Σ(1940)**							+ -	
	4	**Σ(1880)** **Σ(1900)**	**Σ(1940)**							+ -	

TABLE 7. Mendeleev-like table of strange baryons Σ2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed: Σ(1670), Σ(1690), Σ(1880)

11. Table of strange baryons Σ3

Neither of the two previous tables include spin 0.5 particle Σ{1193} that played a pivotal role in uncovering the Eightfold Way which in turn lead to the concept of the strange quark. This third sigma table is less populated than the previous two, but it has seven particles that fit very well, especially considering the very small measurement errors of Σ{1193} showing as a single line in figure 16. This is similar to Σ(1385), another key particle concerning the strange quark in figure 12.

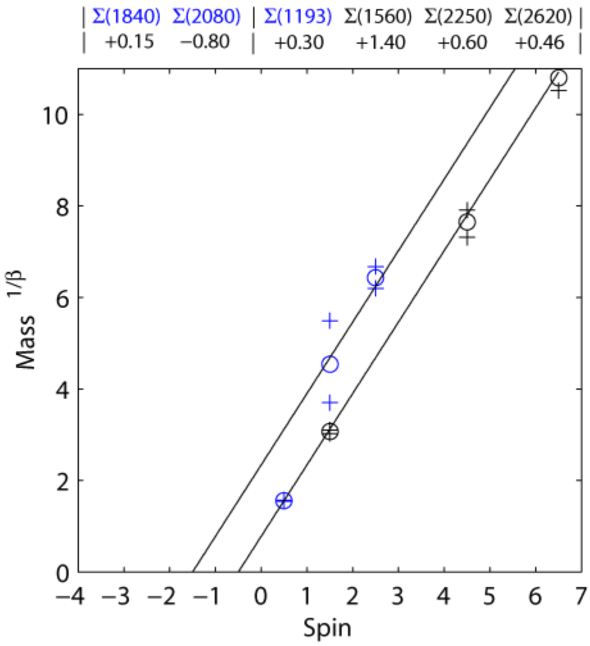

FIGURE 16. Positive parity Σ3

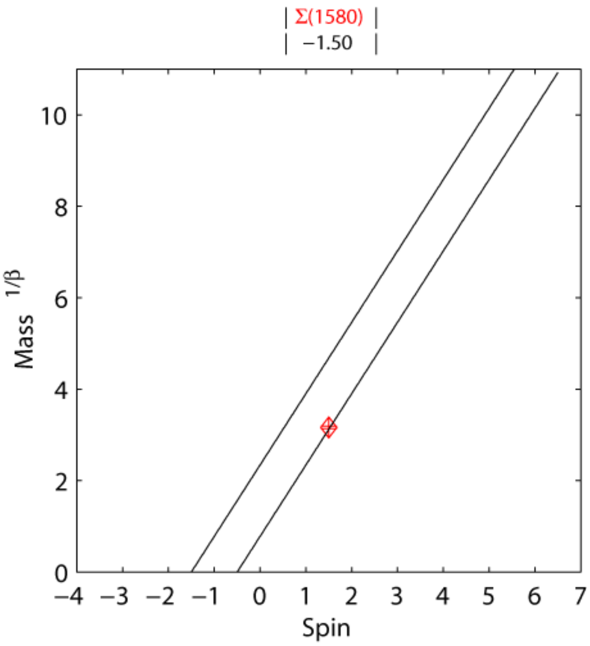

FIGURE 17. Negative parity Σ3

Size b = 0.906		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.398	
Contras	0									+ -	Parity
	1	**Σ{1193}**	**Σ(1560)** **Σ(1580)**			**Σ(2250)**		**Σ(2620)**		+ -	
	2		**Σ(1840)**	**Σ(2080)**						+ -	
	3									+ -	
	4									+ -	

TABLE 8. Mendeleev-like table of strange baryons Σ3

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed: Σ(1560), Σ(1580), Σ(1840), Σ(2080)

Summary particles missing:
Listings particles missing: Σ(1620), Σ(1730), Σ(1480)

12. Table of strange baryons Ξ1

Xi particles have strangeness = -2. Particles Ξ are much fewer than in the previous families, however they still have a reasonably good fit. The table contains spin 0.5 particle Ξ{1318} that together with Σ{1193} played a pivotal role in uncovering the Eightfold Way which in turn lead to the concept of the strange quark. The measurement errors of Ξ{1318} are very small showing as a single line in figure 18.

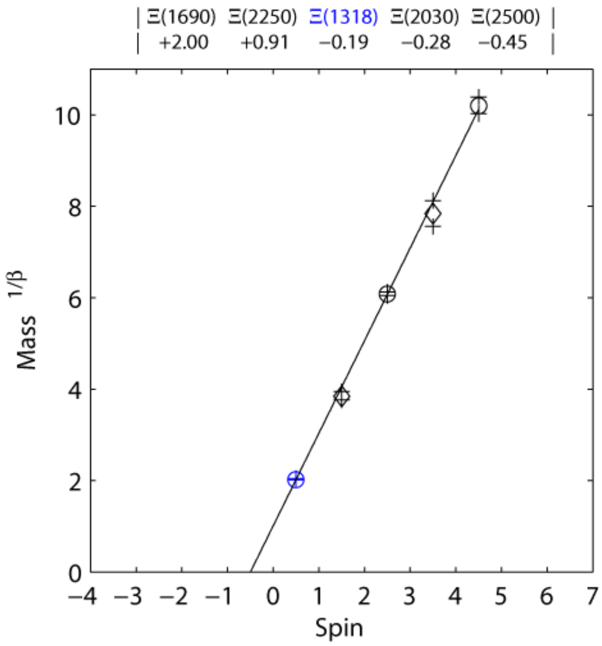

FIGURE 18. Positive and negative parity Ξ1

Size b = 1.000		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.391	
C	0									+ -	
o n	1	**Ξ{1318}**	**Ξ(1690)**	**Ξ(2030)**	**Ξ(2250)**	**Ξ(2500)**				+ -	P a
t r	2									+ -	r i
a s	3									+ -	t y
	4									+ -	

TABLE 9. Mendeleev-like table of strange baryons Ξ1

Summary limits re-computed: Ξ(1690)
Listings limits re-computed:
Listings limits 1st-computed: Ξ(2250), Ξ(2500)

Summary particles missing:
Listings particles missing:

13. Table of strange baryons Ξ2

The Xi table on the previous page does not contain spin 1.5 particle Ξ(1530) which is included here. This particle also played a pivotal role in uncovering the Decuplet pattern which in turn lead to the concept of the strange quark. This table has only one less particle than the previous and the graphs are very similar. As in the case of Ξ(1318) in figure 18 the measurement errors for Ξ(1530), are very small showing as a single line in figure 19.

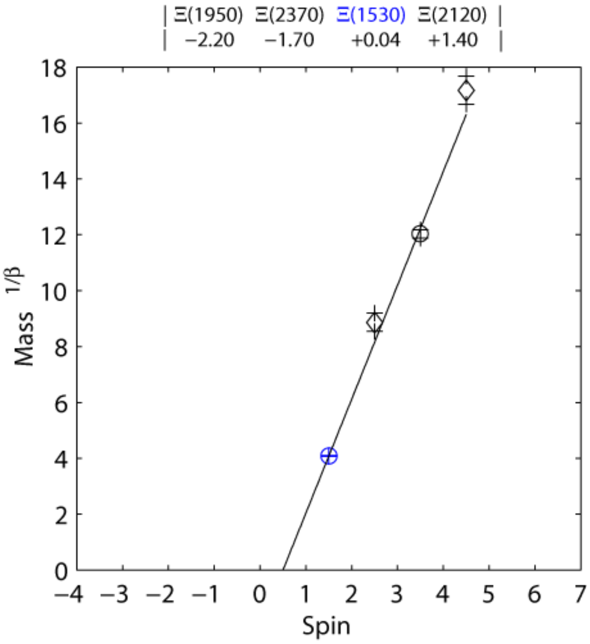

FIGURE 19. Positive and negative parity Ξ2

Size		Spin								Shape	
b = 1.080		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	β = 0.354	
Contras	0		**Ξ(1530)**	**Ξ(1950)**	**Ξ(2120)**	**Ξ(2370)**				+ -	Parity
	1									+ -	
	2									+ -	
	3									+ -	
	4									+ -	

TABLE 10. Mendeleev-like table of strange baryons Ξ2

Summary limits re-computed: Ξ(1950)
Listings limits re-computed:
Listings limits 1st-computed: Ξ(2120), Ξ(2370)

Summary particles missing: Ξ(1820)
Listings particles missing: Ξ(1620)

14. Table of mesons *a*1 and ρ1

Unflavoured mesons ***a*** and **ρ** belong to the same family and for historic reasons ***a*** have even spin while **ρ** have odd spin, although there may be one or two peculiar exceptions. Being unflavoured mesons, in our theory their top and bottom parts have the same structure. This means that for an odd σ we can have only odd spins, while for an even σ we can have only even spins. Thus ρ_3(1690) and ρ_1(1700) may have the same mass with different spin, since they both have odd spin. However, there cannot be a particle with the same mass and spin 2, as indicated in the table below in row two by grey shading.

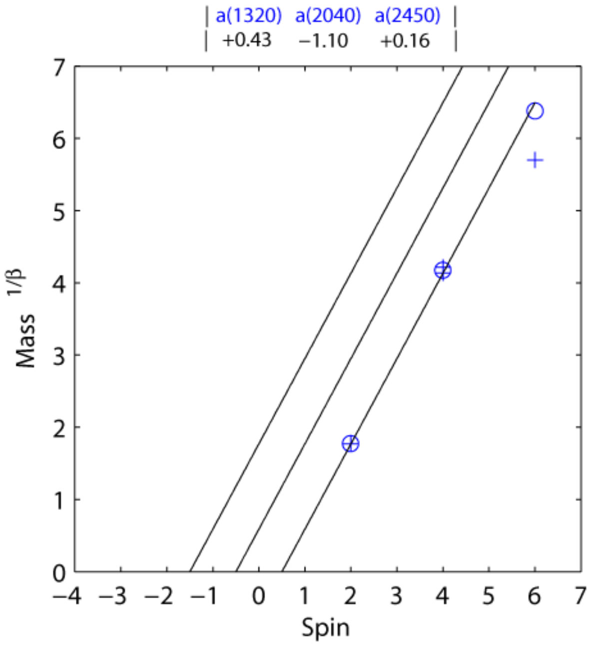

FIGURE 20. Positive parity *a*1

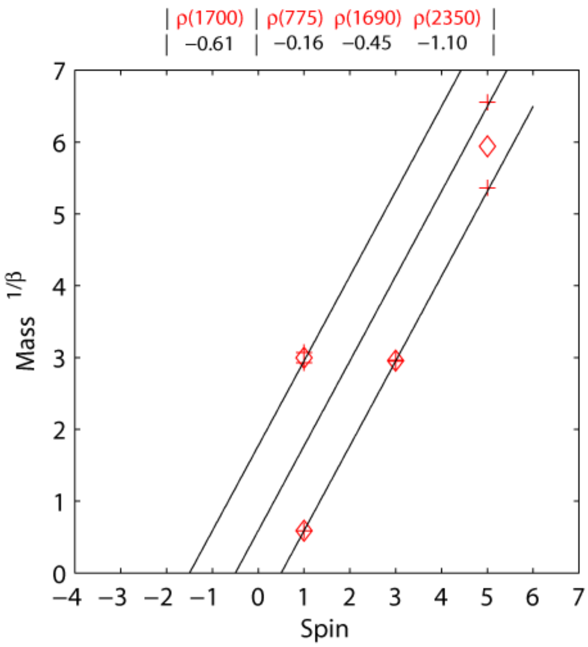

FIGURE 21. Negative parity ρ1

Size b = 0.775		Spin 0	1	2	3	4	5	6	7	Shape β = 0.483	
Contras	0		**ρ_1{775}**	**a_2(1320)**	**ρ_3(1690)**	**a_4(2040)**	**ρ_5(2350)**	**a_6(2450)**		+ -	Parity
	1									+ -	
	2		**ρ_1(1700)**							+ -	
	3									+ -	
	4									+ -	

TABLE 11. Mendeleev-like table of mesons a1 and ρ1

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed: ρ(2350)

15. Table of mesons *a*2 and ρ2

Not all ***a*** and ρ particles fit into the table on the previous page. Those few that don't are shown in the graphs and in the table below. By the rules described on the previous page particle a_0(1450) having an even spin should not be allowed because it has the same mass as ρ_1(1450) with odd spin. However, a spin zero particle can always have the same mass as a particle with a higher spin, since it can be obtained by the top and the bottom rotating in the opposite way. This exception is indicated in the table below.

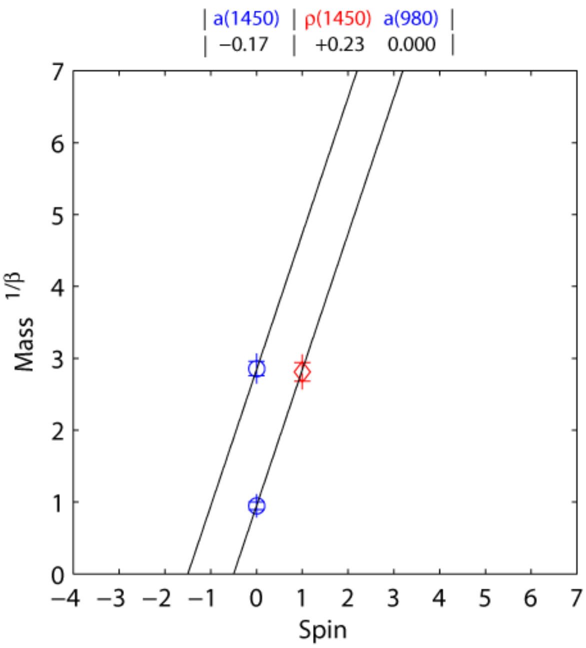

FIGURE 22. Positive and negative parity a2 and ρ2

Size b = 0.980		Spin 0	1	2	3	4	5	6	7	Shape β = 0.370	
Contras	0									+ -	Parity
	1	**a_0(980)**	**ρ_1(1450)**							+ -	
	2	**a_0(1450)**								+ -	
	3									+ -	
	4									+ -	

TABLE 12. Mendeleev-like table of mesons a2 and ρ2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing:
Listings particles missing:

Particle a_1(1260) included in PDG Summary is ignored because normally a particles have even spin.

16. Table of mesons f1 and ω1

Unflavoured mesons **f** and **ω** belong to the same family and for historic reasons **f** have even spin while **ω** have odd spin, although there may be one or two peculiar exceptions, as in the case of ***a*** and **ρ** family. Again, these particles can occupy only every other graph line and in consequence only every other row in the table. Spin zero particles are an exception to this rule, as demonstrated in this family by the presence of f_0(500), and f_0(1370).

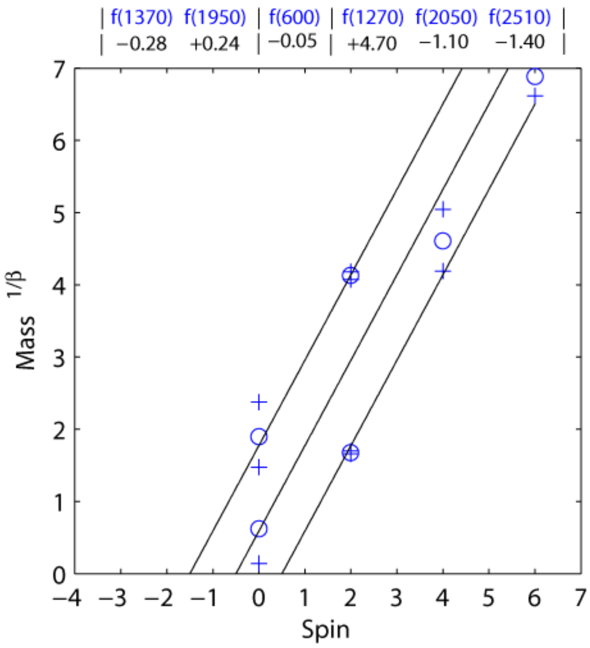

FIGURE 23. Positive parity f1

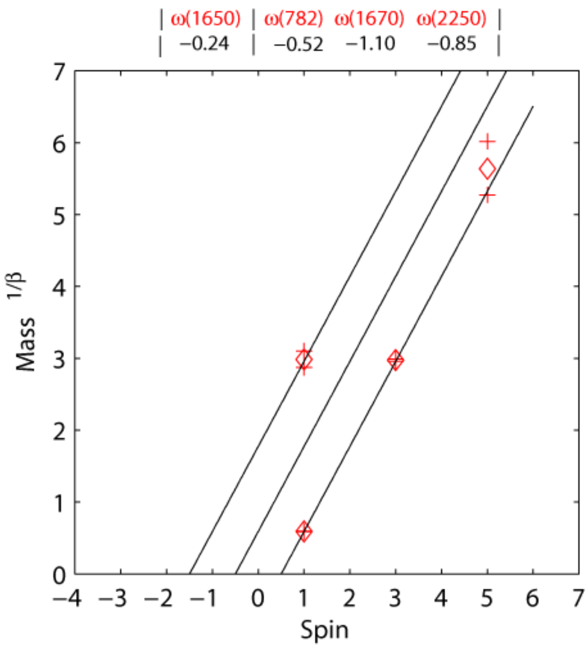

FIGURE 24. Negative parity ω1

Size b = 0.782		Spin 0	1	2	3	4	5	6	7	Shape β = 0.469	
C	0		**ω_1(785)**	**f_2(1270)**	**ω_3(1670)**	**f_4(2050)**	**ω_5(2250)**	**f_6(2510)**		+ -	
o n	1	**f_0(500)**								+ -	P a
t r	2	**f_0(1370)**	**ω_1(1650)**	**f_2(1950)**						+ -	r i
a s	3									+ -	t y
	4									+ -	

TABLE 13. Mendeleev-like table of mesons f1 and ω1

Summary limits re-computed: ω_1(782), f_2(1270), f_4(2050), f_6(2510)
Listings limits re-computed:
Listings limits 1st-computed:

17. Table of mesons f2 and ω2

There are considerably more particles **f** than **ω** and as a result in the table below we have the same number of **f** particles as in the table on the previous page but not a single **ω** particle. This table confirms that with the exception of spin 0 particles the other particles can occupy only every other row.

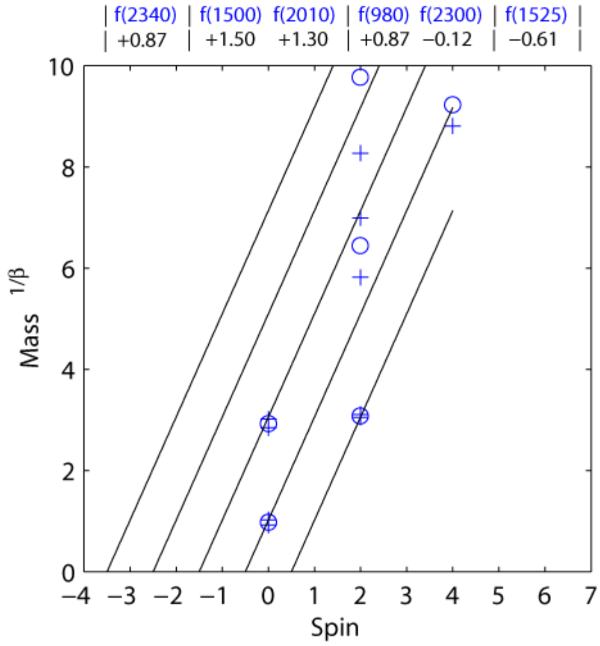

FIGURE 25. Positive and negative parity f2 and ω2

Size b = 1.010		Spin 0	1	2	3	4	5	6	7	Shape β = 0.375	
Contras	0			**$f'_2(1525)$**						+ -	Parity
	1	**$f_0(980)$**								+ -	
	2	**$f_0(1500)$**		**$f_2(2010)$**		**$f_4(2300)$**				+ -	
	3									+ -	
	4			**$f_2(2340)$**						+ -	

TABLE 14. Mendeleev-like table of mesons f2 and ω2

Summary limits re-computed: $f_0(1500)$, $f_2(2340)$
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: $\omega_1(1420)$, $f_0(1710)$, $f_2(2300)$
Listings particles missing: $f_J(2220)$ (J stands for spin 2 or 4)

Particles $f_1(1285)$, $f_1(1420)$ in PDG Summary are ignored because normally f particles have even spin.

18. Table of strange mesons K1

All K particles have strangeness = +1. This mesons displays a very different pattern to the unflavoured mesons, in as much that the particles may occupy every table row, as shown in table 15 below. A possible explanation is that they have symmetrical shape as other particles, but are asymmetric in such a way that the top part may have a different structure to the bottom part. Thus if we consider a particle where every part rotates the same way and then make the top part of the centre rotate in the opposite direction this would reduce the spin of the particle by 1 unit, but retain the same shape and mass.

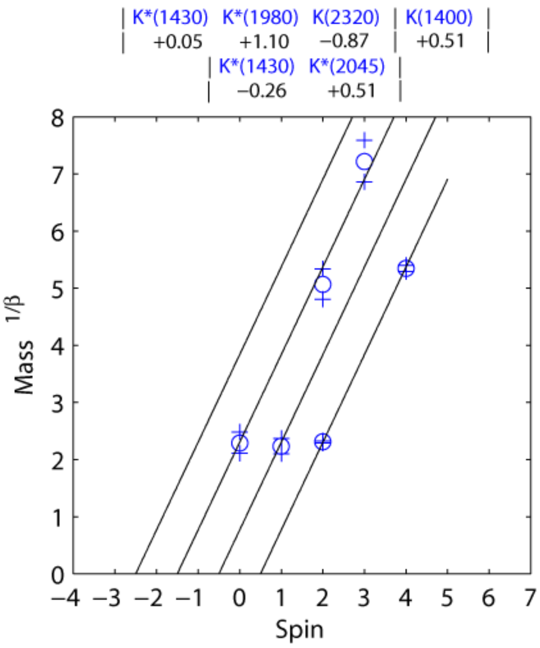

FIGURE 26. Positive parity K1

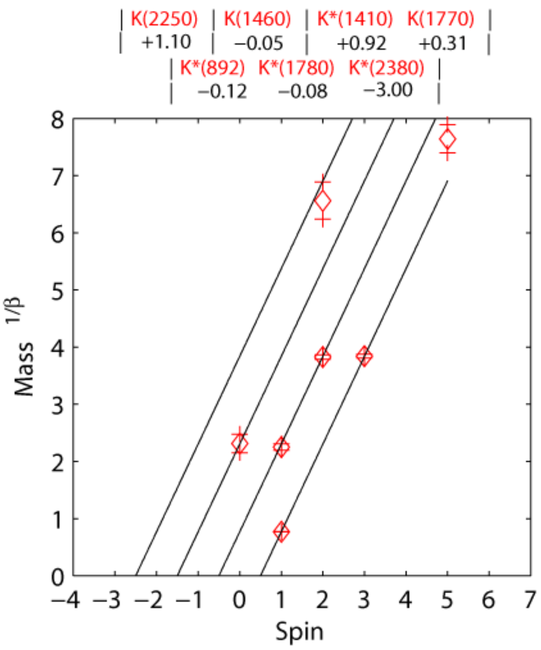

FIGURE 27. Negative parity K1

Size b = 0.893		Spin 0	1	2	3	4	5	6	7	Shape β = 0.417	
Contras	0		K*(892)	K*(1430)	K*(1780)	K*(2045)	K*(2380)			+ / -	Parity
	1		K(1400) K*(1410)	K(1770)						+ / -	
	2	K*(1430) K(1460)		K*(1980)	K(2320)					+ / -	
	3			K(2250)						+ / -	
	4									+ / -	

TABLE 15. Mendeleev-like table of strange mesons K1

Summary limits re-computed: K_1(1400), K_2^*(1980), K_2(2250)
Listings limits re-computed: K_3(2320), K_0(1460)
Listings limits 1st-computed:

19. Table of strange mesons K2

As with most particle families already considered one table does not usually account for all the known particles belonging to a family. This second table of strange mesons confirms the pattern found in the table on the previous page, namely that the particles are not confined to every other table row, as can be seen on the table below.

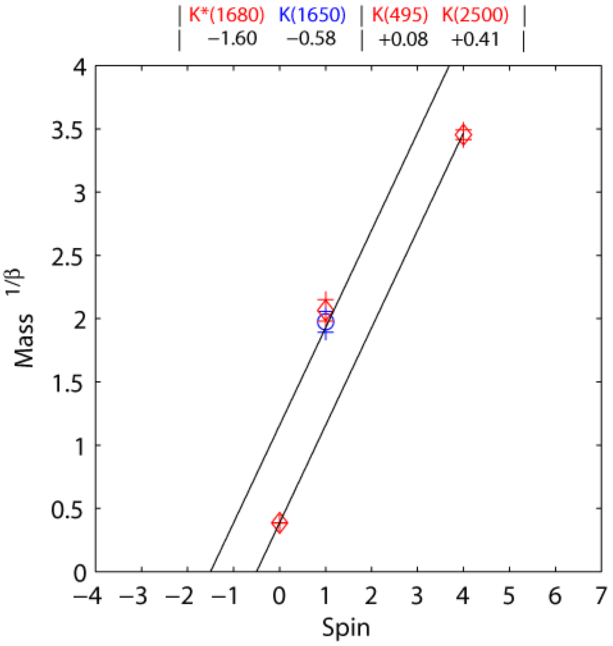

FIGURE 28. Positive and negative parity K2

Size b = 0.496		Spin 0	1	2	3	4	5	6	7	Shape β = 0.736	
Contras	0									+ -	Parity
	1	**K{495}**				**K(2500)**				+ -	
	2		**K(1650)** **K*(1680)**							+ -	
	3									+ -	
	4									+ -	

TABLE 16. Mendeleev-like table of strange mesons Kx

Summary limits re-computed: $K_1^*(1680)$
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: $K_1(1270)$, $K_2(1820)$
Listings particles missing: $K_0^*(1950)$

20. Table of charmed baryons Λc1

The families of charmed particles, with one or two exceptions, are much smaller than the plain and the strange families. The family Λc consist of only six particles. As most families already shown, this one is also split into two tables, which consequently are very sparse.

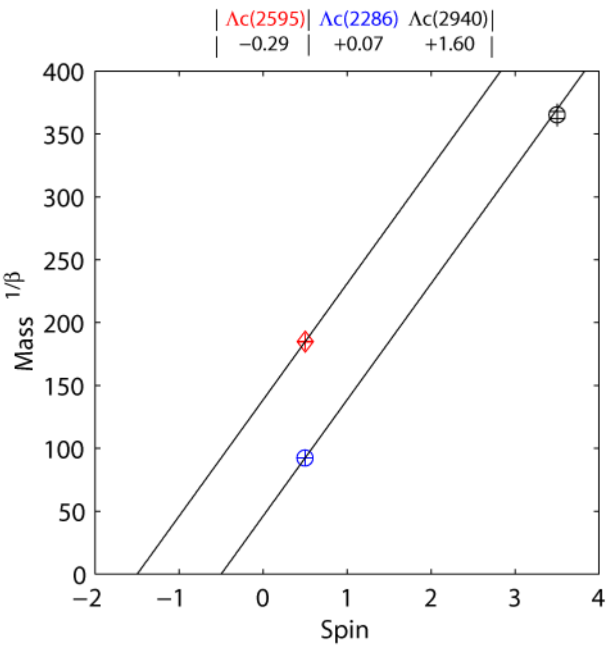

FIGURE 29. Positive and negative parity Λc1

Size		Spin								Shape	
b = 2.01		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	β = 0.183	
Contras	0									+ -	Parity
	1	Λc(2286)			**Λc(2940)**					+ -	
	2	Λc(2595)								+ -	
	3									+ -	
	4									+ -	

TABLE 17. Mendeleev-like table of charmed baryons Λc1

Summary limits re-computed: Λc(2940)
Listings limits re-computed:
Listings limits 1st-computed:

21. Table of charmed baryons Λc2

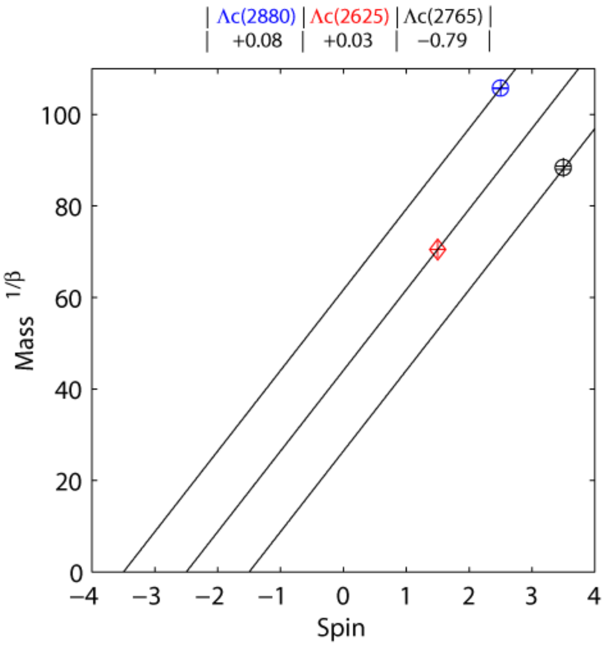

FIGURE 30. Positive and negative parity Λc2

Size b = 1.64		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.227	
Contras	0									+ -	Parity
	1									+ -	
	2				**Λc(2765)**					+ -	
	3		**Λc(2625)**							+ -	
	4			**Λc(2880)**						+ -	

TABLE 18. Mendeleev-like table of charmed baryons Λc2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing:
Listings particles missing:

22. Table of charmed baryons Σc1

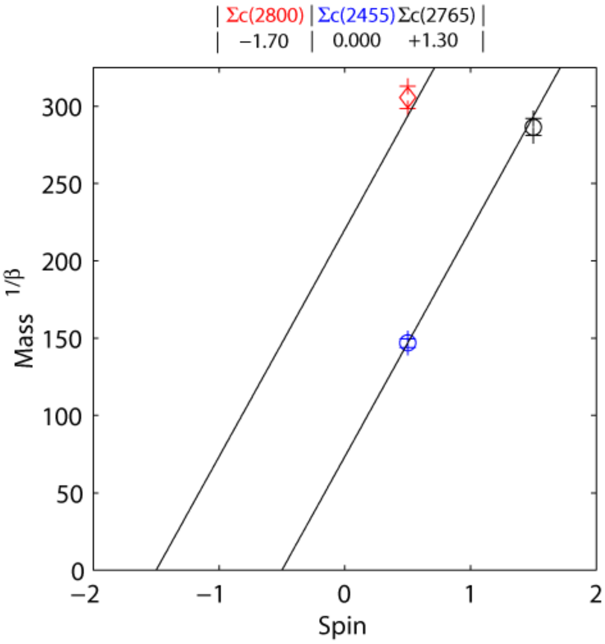

FIGURE 31. Positive and negative parity Σc1

Size b = 2.17		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.180	
Contras	0									+ -	Parity
	1	**Σc(2455)**	**Σc(2765)**							+ -	
	2	**Σc(2800)**								+ -	
	3									+ -	
	4									+ -	

TABLE 19. Mendeleev-like table of charmed baryons Σc1

Summary limits re-computed: limits for Σc(2455), Σc(2765) proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: Σc(2520)
Listings particles missing:

23. Table of charmed baryons Ξc1

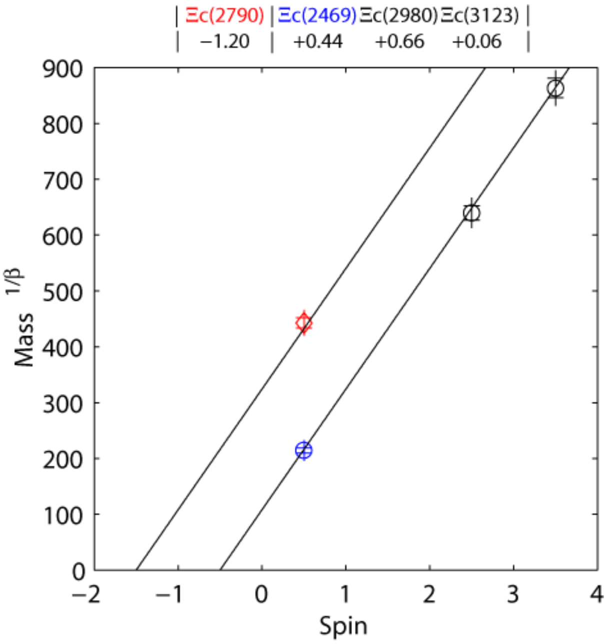

FIGURE 32. Positive and negative parity Ξc1

Size b = 2.20		Spin 0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	Shape β = 0.168	
Contras	0									+ -	Parity
	1	Ξc(2469)		Ξc(2980)	Ξc(3123)					+ -	
	2	Ξc(2790)								+ -	
	3									+ -	
	4									+ -	

TABLE 20. Mendeleev-like table of charmed baryons Ξc1

Summary limits re-computed: limits for all four particles proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

24. Table of charmed baryons Ξc2

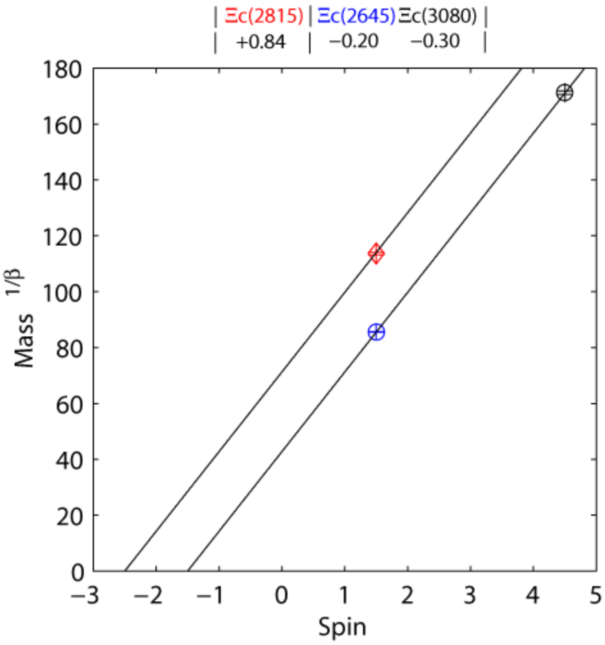

FIGURE 33. Positive and negative parity Ξc2

Size b = 1.79		Spin								Shape β = 0.219	
		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5		
Contras	0									+	Parity
										-	
	1									+	
										-	
	2		**Ξc(2645)**			**Ξc(3080)**				+	
										-	
	3									+	
			Ξc(2815)							-	
	4									+	
										-	

TABLE 21. Mendeleev-like table of charmed baryons Ξc2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: Ξ’c{2576}, Ξc(3055)
Listings particles missing: Ξc(2930)

25. Table of charmed mesons D1

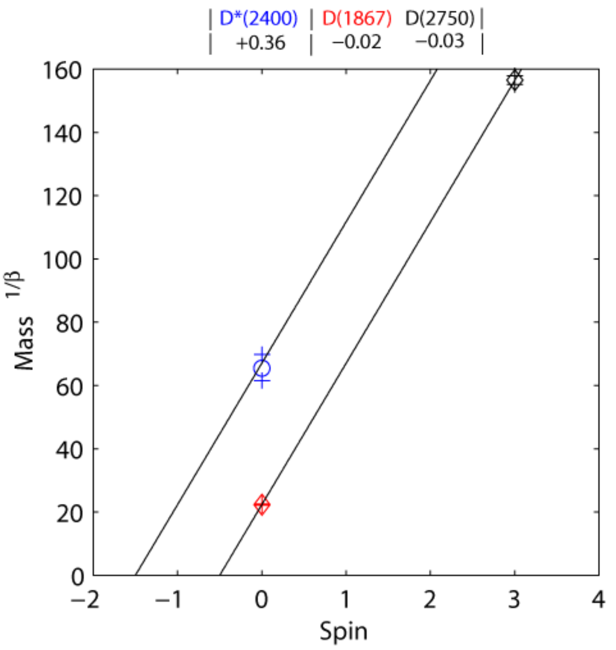

FIGURE 34. Positive and negative parity D1

Size b = 1.87		Spin 0	1	2	3	4	5	6	7	Shape β = 0.201	
Contras	0									+ -	Parity
	1	D(1876)			D(2750)					+ -	
	2	D(2400)								+ -	
	3									+ -	
	4									+ -	

TABLE 22. Mendeleev-like table of charmed mesons D1

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

26. Table of charmed mesons D2

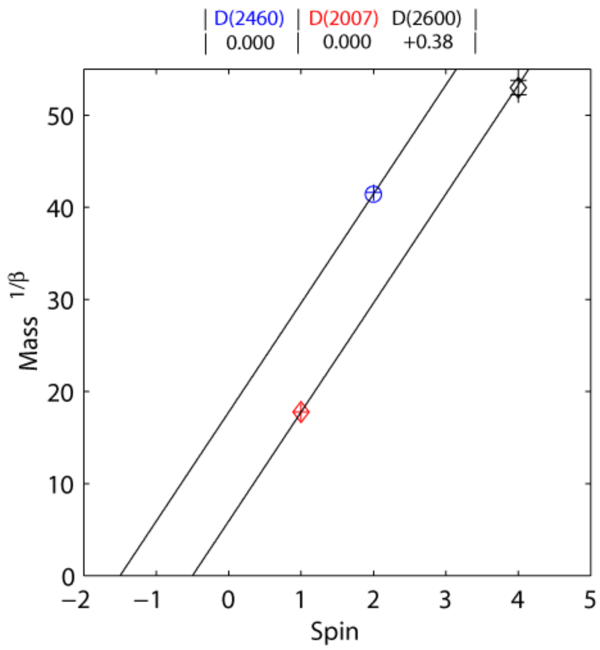

FIGURE 35. Positive and negative parity D2

Size b = 1.54		Spin 0	1	2	3	4	5	6	7	Shape β = 0.242	
Contras	0									+ -	Parity
	1		**D(2007)**			**D(2600)**				+ -	
	2			**D(2460)**						+ -	
	3									+ -	
	4									+ -	

TABLE 23. Mendeleev-like table of charmed mesons D2

Summary limits re-computed:
Listings limits re-computed: D(2600)
Listings limits 1st-computed:

Summary particles missing: D_1(2420)
Listings particles missing: D(2550), D*(2640)

27. Table of charmed mesons Ds1

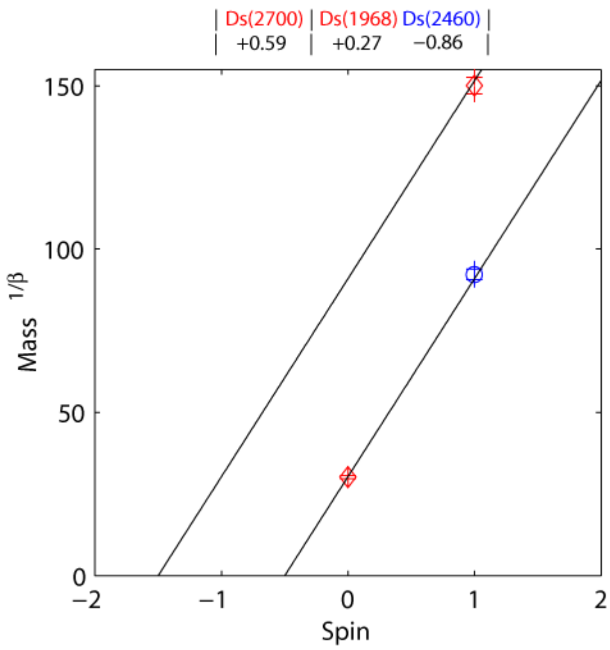

FIGURE 36. Positive and negative parity Ds1

Size		Spin								Shape	
b = 1.97		0	1	2	3	4	5	6	7	β = 0.199	
Contras	0									+ -	Parity
	1	Ds(1968)	Ds(2460)							+ -	
	2		Ds(2700)							+ -	
	3									+ -	
	4									+ -	

TABLE 24. Mendeleev-like table of charmed mesons Ds1

Summary limits re-computed: limits for all three particles proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

28. Table of charmed mesons Ds2

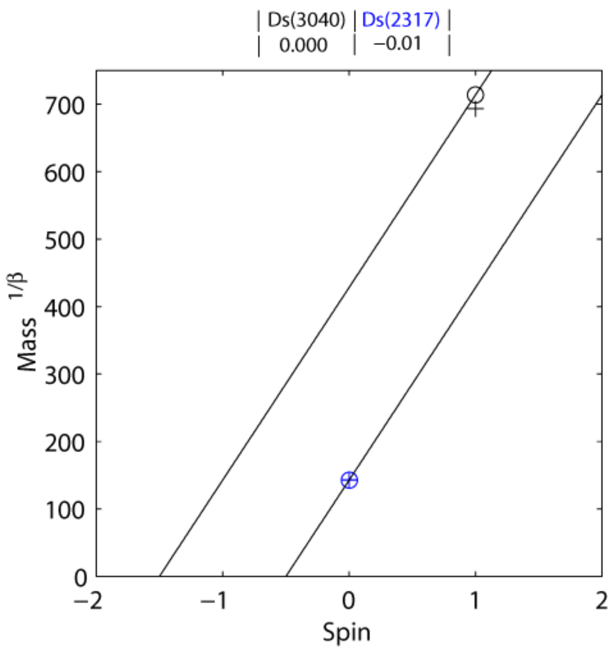

FIGURE 37. Positive and negative parity Ds2

Size b = 2.32		Spin								Shape β = 0.169	
		0	1	2	3	4	5	6	7		
Contras	0									+ -	Parity
	1	Ds(2317)								+ -	
	2		**Ds(3040)**							+ -	
	3									+ -	
	4									+ -	

TABLE 25. Mendeleev-like table of charmed mesons Ds2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

29. Table of charmed mesons Ds3

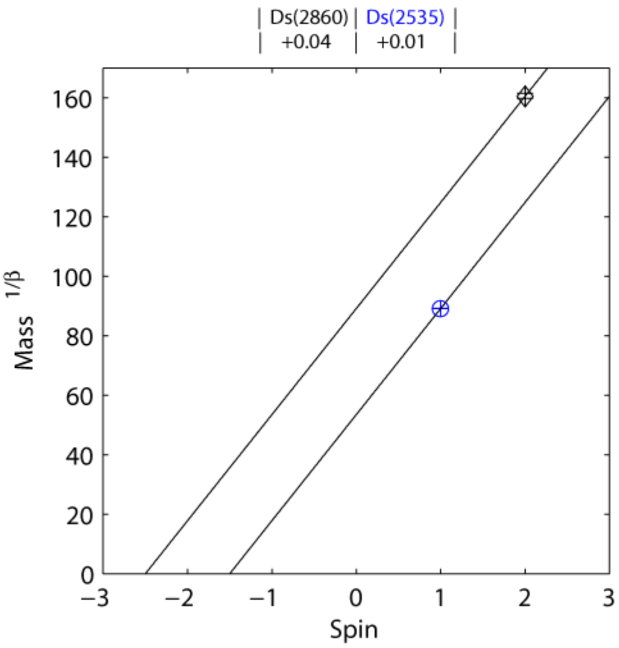

FIGURE 38. Positive and negative parity Ds3

Size b = 2.32		Spin								Shape β = 0.169	
		0	1	2	3	4	5	6	7		
Contras	0									+ -	Parity
	1									+ -	
	2		Ds(2535)							+ -	
	3			Ds(2860)						+ -	
	4									+ -	

TABLE 26. Mendeleev-like table of charmed mesons Ds3

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: D*s(2112), Ds_2(2573)
Listings particles missing:

30. Table of charmonium mesons X1

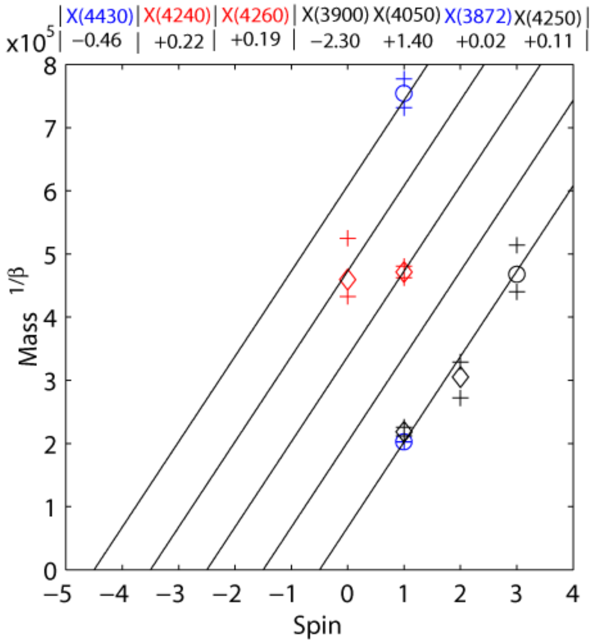

FIGURE 39. Positive and negative parity X1

Size b = 3.43		Spin								Shape β = 0.111	
		0	1	2	3	4	5	6	7		
Contras	0									+ -	Parity
	1		**X(3872)** **X(3900)**	**X(4500)**	**X(4250)**					+ -	
	2									+ -	
	3		**X(4260)**							+ -	
	4	**X(4240)**								+ -	
	5		**X(4430)**							+ -	

TABLE 27. Mendeleev-like table of charmonium mesons X1

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

31. Table of charmonium mesons X2

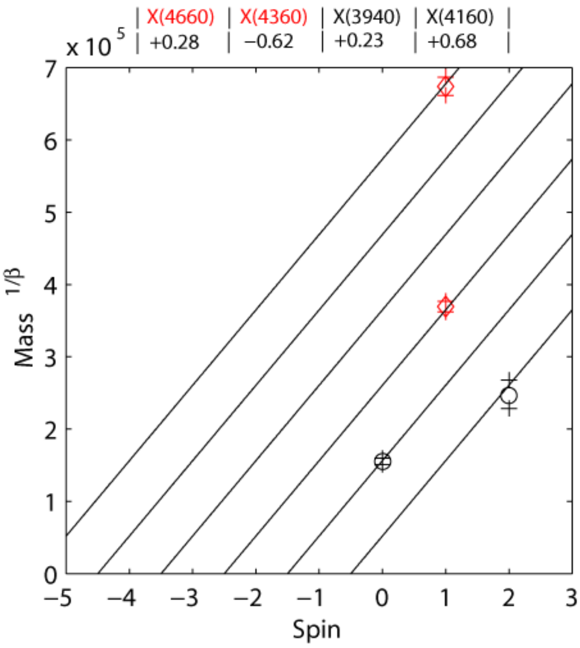

FIGURE 40. Positive and negative parity X2

Size b = 3.48		Spin 0	1	2	3	4	5	6	7	Shape β = 0.115	
Contras	0									+ -	Parity
	2	**X(3940)**		**X(4160)**						+ -	
	3									+ -	
	4		**X(4360)**							+ -	
	5									+ -	
	6									+ -	
	7		**X(4660)**							+ -	

TABLE 28. Mendeleev-like table of charmonium mesons X2

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing:
Listings particles missing: X(3823), X(4020), X(4230)

32. Table of charmomium mesons χc1 and ψc1

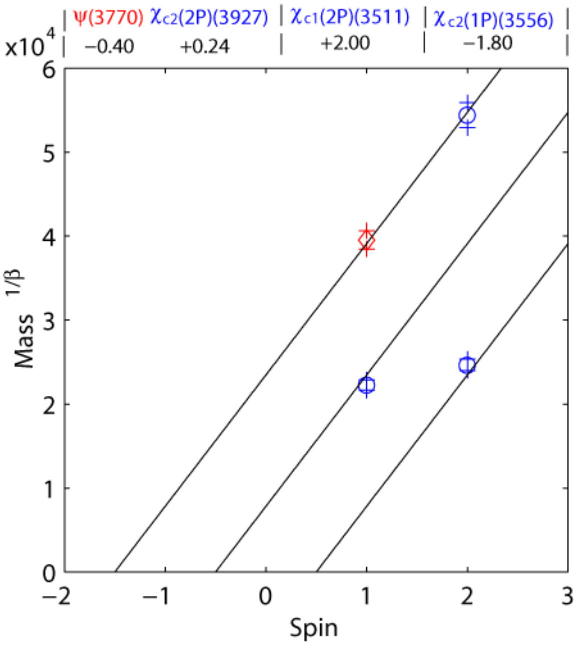

FIGURE 41. Positive and negative parity χ1 and ψ1

Size b = 3.08		Spin 0	Spin 1	Spin 2	Spin 3	Shape β = 0.125	
Contras	0			χc2(1P)(3556)		+ -	Parity
	1		χc1(2P)(3511)			+ -	
	2		ψ(3770)	χc2(2P)(3927)		+ -	
	3					+ -	
	4					+ -	

TABLE 29. Mendeleev-like table of charmed mesons χ1 and ψ1

Summary limits re-computed: limits for all four particles proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

33. Table of charmonium mesons χc2 and ψc2

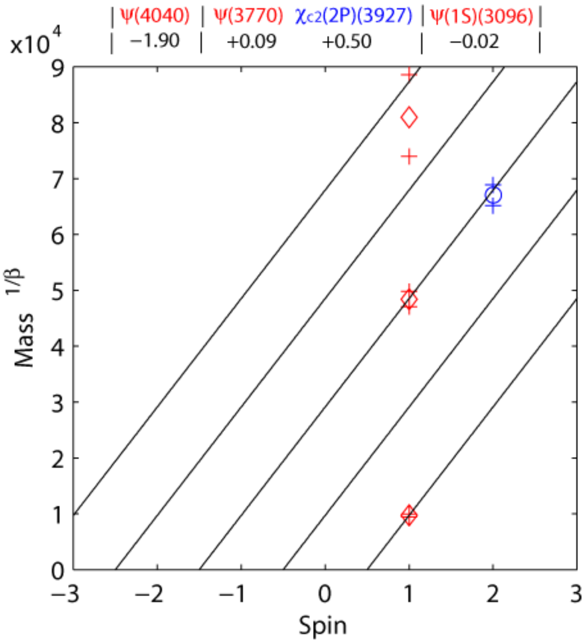

FIGURE 42. Positive and negative parity χ2 and ψ2

Size b = 3.10		Spin 0	Spin 1	Spin 2	Spin 3	Shape β = 0.123	
Contras	0		**ψ(1S)(3096)**			+ -	Parity
	1					+ -	
	2		**ψ(3770)**	**χc2(2P)(3927)**		+ -	
	3					+ -	
	4		**ψ(4040)**			+ -	

TABLE 30. Mendeleev-like table of charmed mesons χ2 and ψ2

Summary limits re-computed: limits for all particles except ψ(4040) proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

34. Table of charmonium mesons χc3 and ψc3

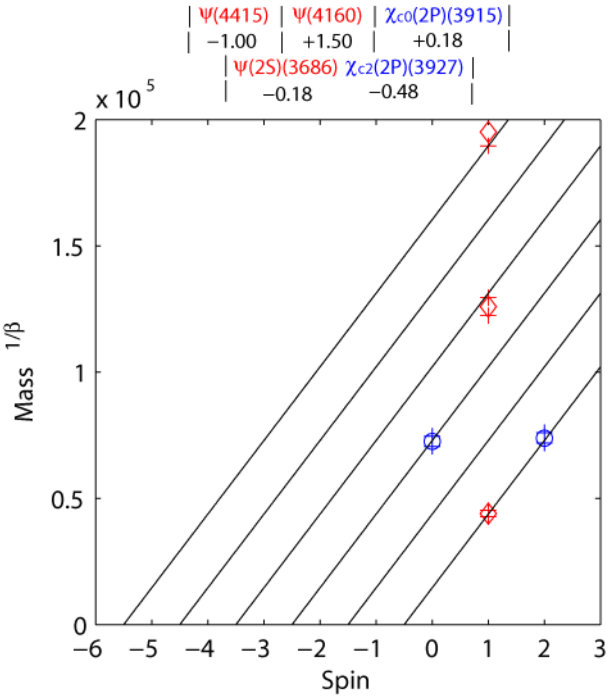

FIGURE 43. Positive and negative parity χ3 and ψ3

Size b = 3.22		Spin 0	1	2	3	Shape β = 0.122	
Contras	0					+ -	Parity
	1		ψ(2S)(3686)	χc2(2P)(3927)		+ -	
	2					+ -	
	3	χc0(2P)(3915)				+ -	
	4		ψ(4161)			+ -	
	5					+ -	
	6		ψ(4415)			+ -	

TABLE 31. Mendeleev-like table of charmed mesons χ3 and ψ3

Summary limits re-computed: limits for all particles proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing: χc0(1P){3415}
Listings particles missing:

35. Table of beuatonium mesons χb1 and Y1

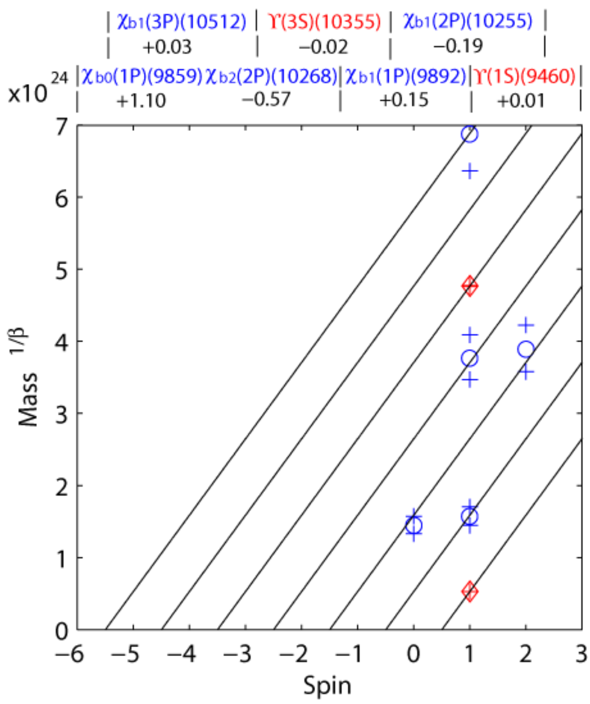

FIGURE 44. Positive and negative parity χb1 and Y1

Size b = 9.46		Spin 0	Spin 1	Spin 2	Spin 3	Shape β = 0.0411	
Contras	0		**Y(1S)(9460)**			+ -	Parity
	1		**χ_{b1}(1P)(9892)**			+ -	
	2	**χ_{b0}(1P)(9859)**		**χ_{b2}(2P)(10268)**		+ -	
	3		**χ_{b1}(2P)(10255)**			+ -	
	4		**Y(3S)(10355)**			+ -	
	5					+ -	
	6		**χ_{b1}(3P)(10512)**			+ -	

TABLE 32. Mendeleev-like table of beautonium mesons χb1 and Y1

Summary limits re-computed: χb0(1P)(9859), χb1(1P)(9892) limits proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

36. Table of beuatonium mesons χb2 and Y2

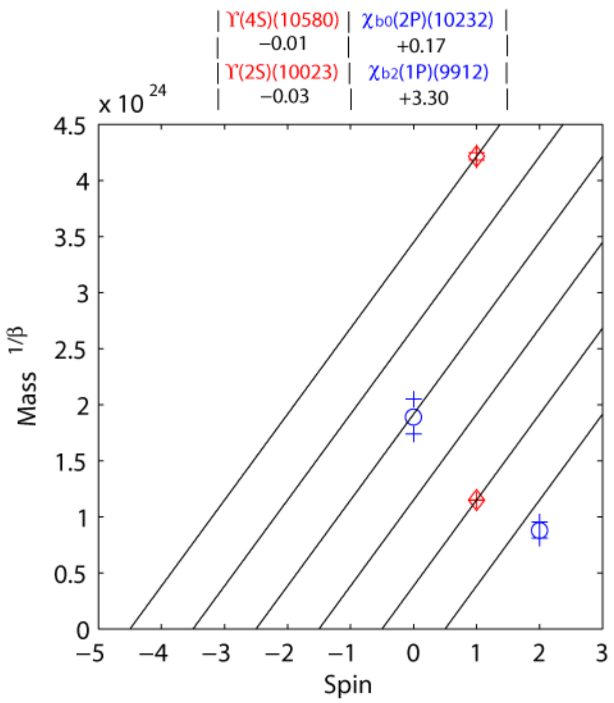

FIGURE 45. Positive and negative parity χb2 and Y2

Size b = 9.57		Spin 0	1	2	3	Shape β = 0.0416	
Contras	0			**χb2(1P)(9912)**		+ -	Parity
	1		**Y(2S)(10023)**			+ -	
	2					+ -	
	3	**χb0(2P)(10232)**				+ -	
	4					+ -	
	5		**Y(4S)(10580)**			+ -	
	6					+ -	

TABLE 33. Mendeleev-like table of beautonium mesons χb2 and Y2

Summary limits re-computed: χb2(1P)(9912), χb0(2P)(10232) limits proportional to Σ{1193}.
Listings limits re-computed:
Listings limits 1st-computed:

37. Table of beuatonium mesons χb3 and Y3

The mass errors indicated by a pair of + signs are vastly magnified on the graph with the straight lines. The true errors are shown on the graph with the curved lines where the pairs of + merge into one + sign. This is more visible here than on other graphs because the mass exponent 1/β ≈ 26 which is very high.

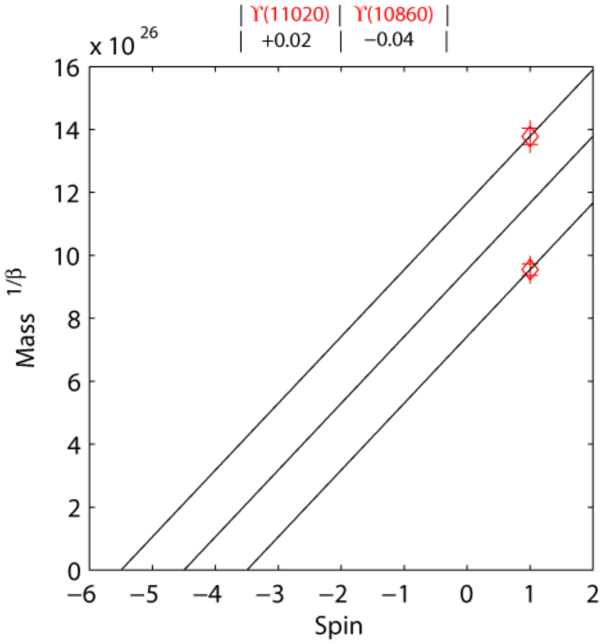

FIGURE 46. Straight lines χb3 and Y3

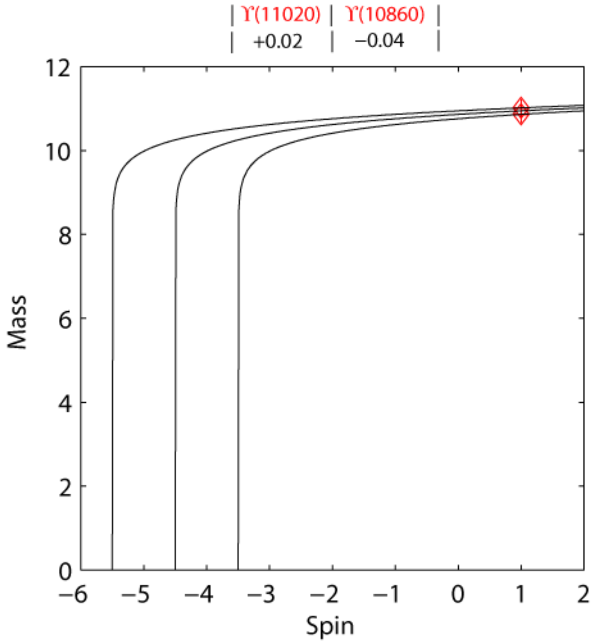

FIGURE 47. Curved lines χb3 and Y3

Size b = 9.99		Spin 0	Spin 1	Spin 2	Spin 3	Shape β = 0.0380	
Contras	0					+ -	Parity
	1					+ -	
	2					+ -	
	3					+ -	
	4		**Y(10860)**			+ -	
	5		**Y(11020)**			+ -	
	6					+ -	

TABLE 34. Mendeleev-like table of beautonium mesons χb3 and Y3

Summary limits re-computed:
Listings limits re-computed:
Listings limits 1st-computed:

Summary particles missing:
Listings particles missing:

38. Analysis of the prediction errors

In section 2 we considered the quality of PDG data and pointed out that the mass limits for a particle are not obtained purely by statistical means. Therefore in situations where RPE is outside the PDG limits (26 particles) or the limits are absent (31 particles) we compute the standard deviation using the experimental results given in PDG Listings. This seems to correct the most skewed PDG limits and judging by the table below on the whole the PDG limits may be considered as the standard deviations.

Table 35 below shows the distribution of the absolute values of the Relative Prediction Errors for the plain and strange particles. The bottom line shows the percentages for the normal Gaussian random errors distribution. These percentages are very similar for the distribution of our relative prediction errors, hence these errors are almost entirely due to the random mass measurements errors.

Table Name	Number of Particles	Absolute Values of RPE		
		(0, 1]	(1, 2]	(2, ∞)
N1	14	14	0	0
N2	13	13	0	0
Δ1	16	15	1	0
Λ1	15	10	5	0
Λ2	4	2	2	0
Σ1	11	10	1	0
Σ2	11	9	2	0
Σ3	7	5	2	0
Ξ1	5	4	1	0
Ξ2	4	1	2	1
aρ1	7	5	2	0
aρ2	3	3	0	0
fω1	10	6	3	1
fω2	6	4	2	0
K1	13	10	2	1
K2	4	3	1	0
All Particles	143	114	26	3
Percentage	100%	79.7%	18.2%	2.1%
Gauss	100%	84.1%	13.6%	2.3%

TABLE 35. Relative Prediction Errors for plain and strange particles

Table 36 on the next page shows the error distribution for the charmed and beauty particles. The percentages there are again very similar to the Gaussian distribution, hence all prediction errors are almost entirely due to the random mass measurements errors.

Table Name	Number of Particles	Absolute Values of RPE		
		(0, 1]	(1, 2]	(2, ∞)
ΛC1	3	2	1	0
ΛC2	3	3	0	0
ΣC1	3	1	2	0
ΞC1	4	3	1	0
ΞC2	3	3	0	0
D1	3	3	0	0
D2	3	3	0	0
DS1	3	3	0	0
DS2	2	2	0	0
DS2	2	2	0	0
X1	7	5	1	1
X2	4	4	0	0
χψ1	4	2	2	0
χψ2	4	3	1	0
χψ3	5	4	1	0
χY1	7	6	1	0
χY2	4	3	0	1
χY3	2	2	0	0
All Particles	66	54	10	2
Percentage	100%	81.8%	15.2%	3.0%
Gauss	100%	84.1%	13.6%	2.3%

TABLE 36. Relative Prediction Errors for charmed and beauty particles

It could be argued that the particles for which no place was found in the tables should be included in the last column. There are 21 such particles not included in the PDG Summary. When we look at them in detail we find that many of them have only one measurement and of those that have more than one measurement only 4 have a measurement taken within the last 12 years. The data is too unreliable and we may consider these particles as outliers.

There are also 18 particles in the PDG Summary that are missing from the tables of which 6 have only one measurement or the latest measurement is over 12 years old. Thus there are 12 particles that should have been included in the tables on the assumption that they have not been misplaced in the first place, an assumption that is not necessarily valid. Since there are 16 families of particles involved, that makes less than one particle per family unaccounted for.

Considering that there are 209 particles in the tables the 12 unaccounted particles with the credible mass data amount to 5.3%.

39. Parameters *b* and β

There is a strong relationship between the parameters b and β in as much that their product $b\beta$ is very close to a constant γ that appears to be a property of the relativistic ether.

$$b\beta = \gamma \qquad \text{where} \qquad \gamma \cong 0.3868 \text{ GeV} \tag{39.1}$$

This can be seen on the linear regression graph with the intercept forced to zero in figure 48 below, which has highly significant statistical parameters $R^2 = 0.9995$ and P-value = 1.57E-55. The parameter R^2 is the correlation coefficient that indicates the closeness of b values to the predicted γ/β. The perfect value for $R^2 = 1$, that can be achieved for any number of pairs involved greater than two, if they exactly fit the line. The P-value gives the probability that the given number of pairs selected at random may result in the obtained value of R^2. Thus P-value = 0 can never be achieved and can only come close to it if a substantial number of the pairs are involved.

In our case the P-value = 1.57E-55 tells us that such a good line fit as we have obtained is virtually impossible by chance without an underlying physical relationship between the parameters b and β.

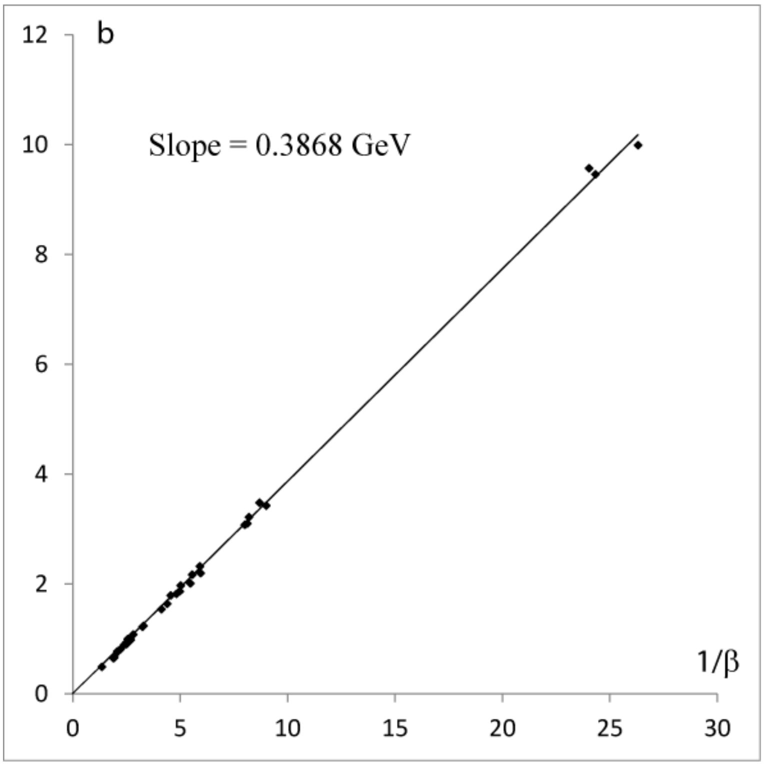

FIGURE 48. b as a function of $1/\beta$

On the graph each marker represents a table. These markers are clustered in four groups. The cluster with the smallest b values consist of the plain and strange particles. The next cluster consist of the charmed particles, but excludes the charmonium particles X and $\chi\psi$. The charmonium particles form the third cluster. The final fourth cluster consist of the heaviest particles, i.e. beautonium particles χY.

40. Parameters *a* and α

Parameters *a* and α appear in the profile function r(z) of the vortex given by formula (2.1) where *a* determines the size and α the shape. Parameter α is related to β by a simple formula (2.10) that was introduced in order to make the mass formula (2.8) simpler. Their relationship is such that

$$\text{for } \alpha > ½ \text{ we have } \beta < 0 \qquad \text{for } \beta > ½ \text{ we have } \alpha < 0 \tag{40.1}$$

The mass formula (2.8) was derived on the assumption that the vortex has an infinite radius, which is clearly unrealistic as a particle cannot span the whole universe. Because particles have a finite radius our mass calculations compensate for the resulting deficit of the particles mass by obtaining a lower value of α which results is a sharper (slimmer) vortex profile. Thus particles with the actual α close to zero acquire negative α as can be seen on the left side of table 37.

The formula for *a* (2.13) involves two parameters *b* and β and we use it to compute the values of *a* in the table below. This formula also assumes that particles have an infinite radius and further that their moment of inertia Iz is finite, which it is only if α < ¼. For α greater than that the formula produces a complex number, hence there are no values for *a* on the right side of the table.

Table Name	*a*	$\alpha < 0$
K2	0.543	-0.136
N1	0.505	-0.018
Σ2	0.503	-0.013
Λ2	0.509	-0.010

Table Name	*a*	$0 < \alpha < 1/4$
aρ2	0.514	0.011
fω1	0.509	0.021
Λ1	0.507	0.034
K1	0.505	0.059
Δ1	0.504	0.071
Σ3	0.498	0.072
Ξ1	0.510	0.078
fω2	0.502	0.091
aρ2	0.494	0.095
Σ1	0.501	0.108
N2	0.490	0.147
Ξ2	0.490	0.150
D2	0.470	0.208
ΛC2	0.460	0.222
ΞC2	0.459	0.231
DS3	0.429	0.243
D1	0.379	0.249

Table Name	*a*	$\alpha > 1/4$
DS1		0.251
ΛC1		0.268
ΣC1		0.271
DS2		0.283
ΞC1		0.284
χψ1		0.333
χψ2		0.336
χψ3		0.337
X2		0.345
X1		0.350
χY2		0.440
χY1		0.441
χY3		0.445

TABLE 37. Parameters *a* and α sorted in ascending order by α

Using the formulas which assume that particles have an infinite radius results in approximations, especially for α > ¼. Further, because *b* and the product $b\beta$ are always positive we can never obtain negative β. We can obtain β as close to zero and hence *b* as large as we like, but we will always have α < ½. This is significant because fluid mechanics tells us that vortices in ideal fluid should have α = ½ and experiments show that water and air vortices have α > ½ , starting from about 0.6. In order to find out how good is the approximation and if the conjecture that particles have α < ½, we will need to minimise the mass prediction errors not only by varying *b* and β but also the radius of the particles.

41. Summary and conclusions

Using the Vir formula for particle mass the masses of 209 particles were calculated with such accuracy that the errors from the actual masses are entirely attributable to the mass measurement errors.

The formula does not yet include the effect of the electric charges on mass, as for example in proton/neutron or Σ^-/ Σ^0/ Σ^+, therefore on such occasions the average mass is used.

For each family of particles there is one or more Mendeleev-like table. The columns correspond to spin values *s* and the rows correspond to the number of particle parts c rotating against the spin. The variables *s* and *c* describe the particle structure, in analogy to Mendeleev tables describing the atomic structure. The implication of this structure is that an empty table cell should in future be filled by a new particle.

The following 16 particle families are included: N, Δ, Λ, Σ, Ξ, aρ, fω, K, Λc, Σc, Ξc, D, Ds, X, χψ, χY. They include the lightest family N and the heaviest family χY. Out of all particles involved that have credible mass data only 12 particles are not in any table, that is 5% of 209 + 12.

Each table is determined by two constants b and β that provide the best possible fit to the actual masses. The constant b is the predicted mass of the lightest particle spin 1 in the given family. The product b times β is approximately the constant $\gamma \approx 0.3868$ GeV.

The constant γ was determined by regression with the correlation factor $R^2 = 0.9995$ and the probability that using the given amount of data this may happen at random P = 10^{-55}. Hence there is only one empirically derived constant, which may well reflect a fundamental property of the relativistic ether.

It has been proven mathematically elsewhere using the Euler-Lagrange equations that the symmetric concave spinning top with the minimum moment of inertia has the shape of twin vortices with the common spin axis connected at the large ends. Vir theory assumes that hadrons are such vortices in the relativistic ether.

Using the Euler equation for the motion of rotating bodies it is found elsewhere that such a twin vortex self-destructs unless the ratio of its moments of inertia Ix/Iz is an integer or half integer. The lowest possible ratio of Ix/Iz is for a planar disk with Ix/Iz = ½. These facts lead to the quantisation of spin.

The mass formula used assumes that particles have an infinite radius, hence the mass prediction is approximate. To find how good is the approximation and if the conjecture that particles have $\alpha < ½$ one will need to minimise the mass prediction errors by varying the radius of particles in addition to b, β.

We find vortices on all scales of Newtonian Mechanics, from tiny eddies in water, dust devils, tornados and hurricanes that contain more energy than the original nuclear bombs. If particles are indeed vortices then it is possible that black holes are vortices too. After all, the only characteristics of black holes are mass, spin and electric charge, which are the main characteristics of particles.

The fact that vortices give least resistance to spinning gives Vir theory the same solid mathematical foundation as have all theories founded on the principle of least effort, i.e. least action. These theories include Optics, Newtonian Mechanics, Special Relativity, General Relativity and Quantum Mechanics.

The fact that the spin-mass formula satisfies the experimental data with the accuracy and on the scale shown in this paper means that the Vir Theory of Elementary Particles has the potential to answer other questions unanswered by the Standard Model.

Acknowledgments

I would like to thank my wife Jo for her loving care without which this work would not have been possible. I thank God for everything.

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