Vir theory of elementary particles

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Abstract. Vir theory of elementary particles is a new theory that constructs a Periodic Table of Particles. It provides a simple way of calculating mass and lifetime of particles from their positions in the table. The calculations agree remarkably well with particle data. The theory is consistent with Quantum Mechanics but goes beyond the Standard Model. It starts from the Principle of Least Action and makes some assumptions about the nature of elementary particles which may be interpreted as explanations of the nature and origins of mass, spin and lifetime.
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1. Introduction

Despite the successes of the Standard Model, it is believed not to be the final word. The theory leaves unanswered some basic questions: why are there so many elementary particles, why do they have their observed pattern of masses, why are the equations for calculating mass so complex that they have no theoretical solution, what is the origin of mass? Supercomputers have recently been used to calculate mass [1] and lifetime [2] for a handful of particles, but it took many months of computation [3] and this method has not been proven for other particles which may require different approximations, we are awaiting faster CPUs and algorithms to test it [4]. There is nothing for particles that is even vaguely similar to Mendeleyev's Periodic Table of Elements, which groups similar elements together, gives us a simple way of working out the atomic mass and provides a clear insight into the structure and nature of atoms.

The author's view is that the above deficiencies are symptoms of a deeper underlying problem, similar to using an unsuitable coordinate system, which results in over-complicated expressions. To solve the problem a new mathematical way of describing particles as vortices is found, which has the additional benefit of potentially being applicable to all observable scales in the universe. The main object of this work is to develop a theory that results in simple relationships between spin, mass and lifetime of particles, and thus obtain a deeper understanding of their nature. The scope of the theory includes all particles, although the paper concentrates on lighter particles in each spin and gives only an outline for particles with spin 0, ½ and for particles with no mass. Currently the effect of the electrical charges on mass and lifetime is not included in the theory.

The main advances of this work are in the construction of the Periodic Table of Particles, which is used to compute mass and lifetime of particles using a pocket calculator. Also, the use of the Principle of Least Action brings elementary particles on the same firm theoretical footing as the other theories of physics used today: Newtonian Mechanics, Relativity and Quantum Mechanics. Finally, the theory offers a new answer to the age old question, namely: What is matter made of? The main body of the paper has two parts, theoretical and experimental. The theoretical part states the assumptions and derives the formulae. The experimental part constructs the Periodic Table of Particles and compares data with theoretical predictions, which are remarkably accurate.

2. Vir

Vir theory brings elementary particles in line with other theories used today by starting from the Principle of Least Action, more precisely, least resistance to spinning, i.e. the least moment of inertia relative to mass. We begin by noticing that every three-dimensional body has three principal axes of rotation, which are perpendicular to each other. To compare like with like we must compare bodies with the same mass and with the same ratio of their moments of inertia Ix : Iy : Iz. With this constraint the body with the least resistance to spinning is an ellipsoid.

The moments of inertia integrals for an ellipsoid satisfy the principle of least action, but an ellipsoid is not a suitable model of an elementary particle. An elementary particle has dual quantum-mechanical nature, it behaves as a bullet and as a wave, it is very localized but also smeared throughout large (in theory infinite) extents of space. An ellipsoid with a finite mass is confined to a finite cube and thus is in no way smeared throughout space.

An alternative, and more appropriate description of elementary particles, is provided by considering the nature of vortices. The eye of a hurricane is much smaller than the clouds spiralling around it and miniscule in comparison to the area over which the hurricane affects the weather. The eye is localized but the hurricane is in a way smeared all over the globe. We are therefore looking for a shape that contains one or more infinite planes but has a finite volume. We shall call Vir a shape resembling two hurricanes, one upside down, connected either at their large or small ends, with a common axis of rotation. If the vortices are connected at their large ends we have a Spindle Vir, which has an infinite plane in its middle, more precisely radius r and height z for the vortex eye are related by:

$$0 < |z| \le Z \qquad r(z) = a \cdot \left(\frac{a}{|z|} \right)^{\alpha} \qquad 0 < a \quad 0 < \alpha < 1/4 \tag{1}$$

If the vortices are connected at their small ends we have a Spool Vir, which has two infinite planes, one at either end, more precisely radius r and height z of the vortex eye are related by:

$$|z| < Z \qquad r(z) = a \cdot \left(\frac{a}{Z - |z|} \right)^{\alpha} \qquad 0 < a \quad 0 < \alpha < 1/4 \tag{2}$$

Spindle Virs have the least resistance to spinning of all bodies that contain one infinite plane, while Spool Virs of all bodies that contain two infinite planes. I am not able to prove this mathematically using the calculus of variations, but neither can I find any counter examples amongst the elementary functions. Furthermore, using Virs leads to such good results that one is compelled to think that Virs must be at least a good approximate solution.

We see vortices with our naked eyes everywhere around us, hurricanes, tornadoes, dust devils, eddies in a stream, etc. Using telescopes we see that the largest objects in the universe, the galaxies, are vortices. Using microscopes we see vortices for which we have no everyday words. Vortices range from the most destructive forces on Earth to the smallest disturbances we can visually observe. Why then should not the smallest objects that we can observe in one way or another, i.e. the elementary particles, be vortices too? If an elementary particle is a vortex then it has no internal structure and cannot be split into its constituents. However, just like eddies, several vortices can merge into one and a single vortex can disintegrate into several vortices.

3. Moments of inertia and mass

To calculate the moments of inertia and mass of any circular body that is symmetrical around xy plane it helps to define the following quantities:

$$\sigma = \frac{I_x}{I_z} \tag{3}$$

$$A = \int_0^Z r^2 dz \tag{4}$$

$$B = \int_0^Z r^4 dz \tag{5}$$

$$C = \int_0^Z r^2 z^2 dz \tag{6}$$

The restrictions on the values of α in (1) and (2) come about because integral B diverges for α ≥ ¼. With the above definitions, assuming constant mass density ǥ, we have the following:

$$m = 2\pi A \,ǥ \tag{7}$$

$$I_z = m\frac{1}{2}\frac{B}{A} \tag{8}$$

$$I_x = m\left(\frac{1}{4}\frac{B}{A} + \frac{C}{A}\right) \tag{9}$$

$$2\sigma - 1 = 4\frac{C}{B} \tag{10}$$

Working out integrals A, B and C for Spindle and Spool Virs, then using formulas (7) and (10) we find that in both cases mass *m* (volume of the eye times the universal density constant ǥ) is :

$$m = \mu(2\sigma - 1)^{\beta} \tag{11}$$

where $\beta = \frac{1-2\alpha}{2+2\alpha}$ $\quad 1/5 < \beta < ½$ (12)

μ is the mass for σ = 1

The shape and size of a Vir is determined by the values of α and *a* in (1) and (2), which in turn determine the values of β and μ in (11). The value of σ in (11) remains undetermined until we fix height Z in (1) and (2). Thus, a Vir corresponds to a family of particles, each particle with a different σ, where the masses are given by (11).

4. Euler's equations of motion

To find the relationship between the moments of inertia and spin we start by investigating Euler's equations of motion for a solid rotating body [7]. From the equations we find that a symmetrical top (Ix = Iy) rotates (spins) about its axis z with a constant angular velocity Ω_z. Axis z precesses at a constant angular velocity Ω_{Pr} and at a constant angle θ with the angular momentum vector M. The movement of axis z creates the surface of a cone and the end of vector z describes a circle in a plane perpendicular to vector M. In the absence of external forces angular momentum vector M is fixed in its magnitude and direction. The assumptions (13) and the solution (14) are below [8]:

$$\overrightarrow{M} = \text{constant} \qquad I_x = I_y \qquad \boldsymbol{I} = \text{constant} \tag{13}$$

$$\Omega_z = \frac{M}{I_z}\cos\theta \qquad \theta = \text{constant} \qquad \Omega_{\text{Pr}} = \frac{M}{I_x} \tag{14}$$

From (14) we find the following relationship between moments of inertia and angular velocities:

$$\frac{\Omega_z}{\Omega_{\text{Pr}}} = \frac{I_x}{I_z}\cos\theta \tag{15}$$

The equations also give us an expression for the angular velocity - Ω_ζ (note the minus sign) with which vector M orbits an observer that is attached to the rotating body [9].

$$\Omega_\zeta = \Omega_z - \Omega_{\text{Pr}}\cos\theta \tag{16}$$

An observer attached to the top in such a way that in the initial state is facing vector M will face vector M again on completion of one precession if Ω_ζ/Ω_{Pr} = n, where n is 1, 2, 3, etc. Number n determines how many times the observer will face vector M during one precession, including the final state, but excluding the initial state. From (16) we get two equivalent return conditions:

$$\frac{\Omega_\zeta}{\Omega_{\text{Pr}}} = n \qquad \frac{\Omega_z}{\Omega_{\text{Pr}}} - \cos\theta = n \tag{17}$$

From (15) and (17) we find another condition for return to the initial state after one precession:

$$\left(\frac{I_x}{I_z} - 1\right)\cos\theta = n \tag{18}$$

For very small θ we have Ix/Iz = n +1 which means that ratio Ix/Iz takes values of 2, 3, 4 etc. The ratio Ix/Iz may also take value 1 in which case n = 0 which means that Ω_ζ = 0 and the observer is facing vector M all the time. Thus, when θ is very small the top returns to its initial state on completion of one precession under the following conditions:

$$\frac{I_x}{I_z} = 1, 2, 3, \text{etc. as } \theta \to 0 \tag{19}$$

The conditions for returning to its initial state only on completion of the second precession are:

$$\frac{\Omega_\zeta}{\Omega_{\mathrm{Pr}}} = \frac{2n-1}{2} - 1 \qquad\qquad \frac{\Omega_z}{\Omega_{\mathrm{Pr}}} - \cos\theta = \frac{2n-1}{2} - 1 \tag{20}$$

$$\left(\frac{I_x}{I_z} - 1\right)\cos\theta = \frac{2n-1}{2} - 1 \tag{21}$$

Number n determines how many times the observer will face vector M during the first two precessions, including the final state, but excluding the initial state. This time there is no solution for n = 0 since that would require negative Ix/Iz. For n = 1 we have $\Omega_\zeta/\Omega_{\mathrm{Pr}} = -1/2$ which means that vector M orbits in the opposite direction to all other values of n. For very small θ this leads to the following possible values of the ratio of the moments of inertia:

$$\frac{I_x}{I_z} = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \text{ etc. as } \theta \to 0 \tag{22}$$

From the definition of the moments of inertia we have, for any body, the following inequality:

$$I_x + I_y \geq I_z \qquad \text{equality for a planar body} \tag{23}$$

For a symmetrical top we have Ix = Iy and therefore from (23) we get the following restriction:

$$\frac{I_x}{I_z} \geq \frac{1}{2} \qquad \text{for any symmetrical top} \tag{24}$$

There is a bottom limit of ½ on the ratio Ix/Iz for a symmetrical top. The limit is reached only by an idealized planar body, for a true three dimensional body the ratio is always greater than ½.
Now, from equation (15) we find that for very small angle θ we have the following relationship:

$$\frac{I_x}{I_z} = \frac{\Omega_z}{\Omega_{\mathrm{Pr}}} \qquad \text{as } \theta \to 0 \tag{25}$$

Therefore, there is a bottom limit on the rotation velocity Ω_z relative to the precession velocity Ω_{Pr} of ½ as θ tends to zero. There in no body that can rotate any slower, relative to precession.

Equation (14) tells us that a body can rotate as slowly as we like when the angle θ tends to 90 degrees. However, only in the limit as θ reaches 90 can the body stop rotating while still precessing. Rotation and precession are inextricably united and can be divorced only at one exact angle (if at all).

An asymmetrical top (Ix not = Iy) never returns to its initial state [10]. Angle θ and all angular velocities Ω vary periodically in time. As θ increases all vectors Ω decrease and vice-versa. Vectors Ω change not only their magnitudes but also their directions. The end of vector z moves on the surface of a unit sphere between two circles lying in two parallel planes perpendicular to vector M, as shown in figure 1.

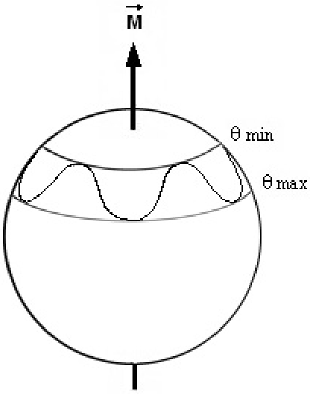

Figure 1. The trajectory of the end of vector z for an asymmetrical top.

Looking from above we see the trajectory of the end of vector z as a periodic *wave* confined between two concentric circles. The trajectory touches the inner circle when θ is at its minimum and the outer circle when θ is at its maximum. The difference between min θ and max θ decreases with the difference between Ix and Iy and disappears when Ix = Iy [11].

Equation (16) still holds at any instant of time, i.e. only for the instantaneous angular velocities. We know that the top never returns to its initial state and to find how close to the initial state it returns we will use the average angular velocities, averaged over the period of one precession. Taking the average over one precession of both sides of equation (16) we get the following:

$$\overline{\Omega_\zeta} = \overline{\Omega_z} - \overline{\Omega_{\mathrm{Pr}} \cos\theta} \qquad (26)$$

Let us write θ and Ω_{Pr} as the time independent average plus the time dependent variation:

$$\theta = \overline{\theta} + \delta \qquad \Omega_{\mathrm{Pr}} = \overline{\Omega_{\mathrm{Pr}}} + \omega \qquad (27)$$

For small variations δ and ω we can expand (26) and neglect terms of the third order to get:

$$\overline{\Omega_\zeta} \approx \overline{\Omega_z} - \overline{\Omega_{\mathrm{Pr}}} + \frac{1}{2}\overline{\Omega_{\mathrm{Pr}}}(\overline{\theta}^2 + \overline{\delta^2}) \qquad (28)$$

The 1st order approximation of (26) is:

$$\overline{\Omega_\zeta} \approx \overline{\Omega_z} - \overline{\Omega_{\mathrm{Pr}}} \cdot \cos\overline{\theta} \quad \text{for} \quad \max\delta << \overline{\theta} << 1 \qquad (29)$$

Equations (16) and (29) are almost identical except that the latter uses the average signs for the angular velocities and the approximately equal sign. Thus, we can use all the expressions obtained for a symmetrical top (14) to (25) by making the same changes to the signs. In what follows, for simplicity, we shall not use the average signs, only the approximate sign.

5. Elementary particles as waves

Euler's equations of motion do not require that the body must be rigid, i.e. that parts of the body remain in constant distance from each other, the conditions are much more relaxed. In the absence of external forces, any internal forces cancel out and the centre of mass of any body moves at a constant velocity. The angular momentum M also remains constant for any body. The angular velocities Ω are associated with the movement of the axes defined by the principal axes of inertia Ix, Iy, Iz. The condition that these must remain constant, i.e. that the body retains its shape, is much less stringent than that the body must be rigid. Hurricanes retain their shape sufficiently well for days or at least hours, tornadoes for minutes and dust devils for tens of seconds, for the equations to apply. The duration we need depends on the precision we require.

For an asymmetrical top the axis z follows a periodic wavy trajectory so that the top generates periodic waves in its environment. If the top is not rigid then the waves that it generates interfere with the top itself. The top effectively becomes a circular wave that is chasing its tail. The head interferes with the tail in a positive or a negative way depending on the phase difference. If the head and tail are in opposite phases the top destroys itself in one precession. If there were no phase difference at all we would get a stationary wave. We know that an asymmetrical top can never return to its initial state exactly, but it can almost return there and the closer it returns to the initial state the longer it will take for the top to destroy itself.

The condition for a near stationary wave is that the top returns near to its initial state on completion of one precession. If the top is symmetrical in xz and yz plane, say it has an elliptical cross-section in xy plane, then it is sufficient that only axis z (not the whole body) returns near to its initial position on completion of one precession, i.e. the top returns near to its initial state on completion of two precessions.

For a symmetrical top the elliptic cross-section becomes circular and its axis describes a circular trajectory without any wavy motion. Such a top does not generate any waves in its surrounding. If such absolutely perfect tops exist in nature as particles then they cannot be detected as waves. We shall therefore consider particles as near symmetrical (Ix = approx Iy) and near vertical (θ = approx 0) spinning tops.

From (17) to (22) and (29) we find that a near symmetrical, near vertical top is a near stationary wave if the following is true:

$$\frac{\Omega_\zeta}{\Omega_{\mathrm{Pr}}} \approx \left(\frac{\Omega_z}{\Omega_{\mathrm{Pr}}} - \cos\theta\right) \approx \left(\frac{I_x}{I_z}\cdot\cos\theta - \cos\theta\right) \approx -\frac{1}{2}, 0, \frac{1}{2}, 1, \frac{3}{2}, 2, etc... \qquad (30)$$

From the above we see that if the ratio $\Omega_z/\Omega_{\mathrm{Pr}}$ was slightly greater than a half integer or an integer it would be possible for the ratio $\Omega_\zeta/\Omega_{\mathrm{Pr}}$ to become exactly a half integer or an integer, in which case we would get an exactly stationary wave. However, this is not possible and therefore we must have the ratio $\Omega_z/\Omega_{\mathrm{Pr}}$ smaller or at most equal to a half integer or an integer.

$$\frac{\Omega_z}{\Omega_{\mathrm{Pr}}} \le \frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, etc... \qquad (31)$$

6. Angular velocities and spin

Vir theory of elementary particles starts from the principle of least resistance to spinning, i.e. it requires the particle to have the least moments of inertia of all bodies with the same mass. We now extend this principle and require that having found such a body, this body must take advantage of its shape and therefore spin with the greatest angular velocity Ωz for the given precession Ω_{Pr}. From this extended principle and the condition (31) we come to the conclusion:

$$\frac{\Omega_z}{\Omega_{\mathrm{Pr}}} = \frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, etc... \tag{32}$$

We thus conclude that the above ratio is the spin and we shall denote it in the usual way by s:

$$s = \frac{\Omega_z}{\Omega_{\mathrm{Pr}}} \tag{33}$$

For the spin angular momentum Mz, i.e. z component of the total angular momentum, we have:

$$M_z = I_z \cdot \Omega_z \tag{34}$$

Since the precession Ω_{Pr} is never zero we can re-write the expression above as follows:

$$M_z = I_z \cdot \Omega_{\mathrm{Pr}} \cdot \left(\frac{\Omega_z}{\Omega_{\mathrm{Pr}}} \right) \tag{35}$$

The condition that the spin angular momentum is half integer or an integer of $\hbar$ is equivalent to:

$$I_z \cdot \Omega_{\mathrm{Pr}} = \hbar \tag{36}$$

This condition effectively says that large bodies precess slowly while small bodies precess quickly. From expressions (33) to (36) we obtain the following Quantum Mechanical condition:

$$M_z = \hbar \cdot s \tag{37}$$

From (33), (15) and (3) it follows that:

$$s = \sigma \cdot \cos\theta \tag{38}$$

For small angles θ we get from (38), by expanding cos, the following approximate relation:

$$\frac{s}{\sigma} \approx 1 - \frac{1}{2}\theta^2 \tag{39}$$

7. Lifetime of particles

A particle is effectively a circular wave that is chasing its tail. The head interferes with the tail in a positive or negative way depending on the phase difference after one precession. If the head and tail are in opposite phases the top destroys itself in just one precession, if we ignore any wave damping effects. From (30) it follows that a particle destroys itself after k precessions if:

$$\frac{\Omega_\zeta}{\Omega_{\text{Pr}}} \approx -\frac{1}{2}, 0, \frac{1}{2}, 1, \frac{3}{2}, 2, etc... \pm \frac{1}{4k} \qquad k = 1,2,3, etc... \qquad (40)$$

The self destruction condition can also be written in terms of $\Omega_z/\Omega_{\text{Pr}}$, again from (30) we get:

$$\frac{\Omega_z}{\Omega_{\text{Pr}}} - \cos\theta \approx \frac{n}{2} \pm \frac{1}{4k} \qquad n = -1,0,1,2,3, etc... \qquad k = 1,2,3, etc... \qquad (41)$$

Using (33) and (38) the above can be written in terms of spin s and moments ratio σ as below:

$$s - \frac{s}{\sigma} \approx \frac{n}{2} \pm \frac{1}{4k} \qquad n = -1,0,1,2,3, etc... \qquad k = 1,2,3, etc... \qquad (42)$$

We now define Δσ as the difference between the moments ratio σ and the spin s as given below:

$$\Delta\sigma = \sigma - s \qquad (43)$$

The self destruction condition in terms of Δσ/σ now becomes:

$$s - 1 + \frac{\Delta\sigma}{\sigma} \approx \frac{n}{2} \pm \frac{1}{4k} \qquad n = -1,0,1,2,3, etc... \qquad k = 1,2,3, etc... \qquad (44)$$

The LHS of (44) is slightly greater than an integer or a half integer and therefore the sign on the RHS must be positive. Thus, there is only one solution for the number of precessions k:

$$\frac{\Delta\sigma}{\sigma} \approx \frac{1}{4k} \qquad k = 1,2,3, etc... \qquad (45)$$

Particles may have a shorter lifetime than given by (45) since they may be destroyed earlier by other forces than self-interference. On the other hand, some particles may have a much longer lifetime than given by (45) as can be seen by considering an electron. Using electron mass m = $5\text{x}10^{-4}$GeV in (11) with μ = 1GeV, β = ½ and s = ½ we get $\Delta\sigma \approx 10^{-7}$. Since σ ≈ ½ we get from (45) that k $\approx 10^6$ and since the lifetime of an electron is around 10^{25} years we get that it takes an electron 10^{19} years to complete one precession. We get this absurd result because we neglected the damping effect, in the absence of damping the amplitude of a circular wave can keep increasing with each precession without bounds, which is clearly wrong. Expression (40) and hence (45) are valid only for relatively short lifetimes, where we can ignore the damping effect.

The time t_{Pr} that it takes to complete one precession is given by the angular velocity Ω_{Pr}:

$$t_{pr} = \frac{2\pi}{\Omega_{\mathrm{Pr}}} \tag{46}$$

For the lifetime τ of a particle in terms of t_{Pr} and the angular velocity Ω_{Pr} we have:

$$\tau = t_{\mathrm{Pr}} \cdot k = \frac{2\pi}{\Omega_{\mathrm{Pr}}} \cdot k \tag{47}$$

From (47) and (36) we get:

$$\tau = \frac{2\pi}{\hbar} \cdot I_z \cdot k \tag{48}$$

The axis of an asymmetrical top oscillates between min θ and max θ and Euler's equations tell us that the difference max θ^2 - min θ^2 is proportional to the difference between Ix and Iy [11], i.e. the elliptical eccentricity of the top. It seems plausible to assume that the average θ^2 is also proportional to |Iy – Ix|. On the basis of Newtonian mechanics it is plausible to argue that due to the centrifugal forces, resulting from the precession movement, a top with a larger Ix will settle at a larger angle θ. It seems therefore plausible to assume that the average θ^2 is proportional to Ix:

$$\theta^2 = c_1 I_x \tag{49}$$

The eccentricity of a given Vir is the same for all σ and therefore the proportionality constant c_1 is the same for all particles belonging to that Vir. From (43) and (39) we get:

$$\frac{\Delta\sigma}{\sigma} \approx \frac{1}{2}\theta^2 \tag{50}$$

From (48), (49), (50) and remembering that σ = Ix/Iz we get:

$$\tau = \frac{2\pi}{\hbar} \cdot \frac{I_x}{\sigma} \cdot k = \frac{2\pi}{\hbar c_1} \cdot \frac{\theta^2}{\sigma} \cdot k \approx c_2 \cdot \frac{\Delta\sigma}{\sigma^2} \cdot k \tag{51}$$

From (51) and (45) we get:

$$\tau \approx c_3 \cdot \frac{1}{\sigma} \tag{52}$$

We usually give lifetime τ of a particle in terms of the full width Γ using the uncertainty relation:

$$\Gamma \cdot \tau = \hbar \tag{53}$$

From (52) and (53) we get:

$$\Gamma \approx \gamma \cdot \sigma \tag{54}$$

For a Vir all particles have the same γ and the full width Γ is proportional to the moments ratio σ. We remind ourselves that formula (54) is not valid for particles with a very long lifetime, say an electron. In addition, it is not valid for particles with spin 1, as will be shown in the next section.

8. Particles with spin one or less

When all three moments of inertia Ix, Iy and Iz are almost identical, i.e. when the top is almost spherical, the solution to Euler's equations of motion is fundamentally different from all other situations. Essentially, we can no longer get an approximate solution by neglecting the terms involving (Ix – Iy) and retaining only the terms with (Iz –Ix) and (Iz – Iy).

We can see that a spherical top is unique also from the fact that its angular velocity Ω_ζ is zero, which means that the observer attached to the top is facing vector M either all the time or never, while for all non-spherical tops the observer faces vector M at periodic time intervals.

The solution (45) for the maximum number of precessions before a particle destroys itself via self-interference does not apply to a near-spherical top. Thus, for spin 1 particles the Vir theory allows varied and quite unrelated width to all other spins and so formula (54) does not apply. To find out what restrictions, if any, apply to the width of spin 1 particles we would have to study the solutions of Euler's equations for almost spherical tops, for which we have no room in this paper.

$$\Gamma \approx \gamma \cdot \sigma \qquad\qquad s \neq 1 \qquad\qquad (55)$$

Until now we have not considered at all particles with spin 0 and only some particles with spin ½, namely only the very light particles that can be viewed as almost planar objects such as an electron, but not the heavy particles such as a proton. The near spherical top gives us the means of including those particles that we have not yet considered.

Effectively, the heavy spin ½ particles can be viewed as near-spherical tops spinning at angle θ of 60 degrees, thus reducing the spin from 1 to ½. Similarly, spin 0 particles can be viewed as near-spherical tops spinning at angle θ of 90 degrees, thus reducing the spin from 1 to 0.

The only particles that we have still not considered are the mass-less particles, namely photons and possibly neutrinos, if indeed they are mass-less.

A Spindle Vir in the limit (as $\alpha \rightarrow 0$) becomes a planar object with the axis of rotation at zero angle θ with the angular momentum vector M, at least as far as we can detect. This is unlike an electron which has detectable mass, is therefore not quite planar, and has a finite angle θ to give spin ½. Such a virtually planar Spindle Vir could be a neutrino with virtually undetectable mass.

A Spool Vir in the limit consists of two planes with the common axis of rotation at zero angle θ with the angular momentum vector M, at least as far as we can detect. As the shape of the Spool Vir tends to its limit the separation of the planes is maintained such that the ratio of Ix/Iz is 1. Such a virtually bi-planar Spool Vir could be a photon with virtually undetectable mass.

9. Periodic table of particles

We shall now construct the Periodic Table of Particles using PDG Summary Tables (2004) [5]. We shall concentrate on the six lightest particles in each spin from 1 upwards. When we plot the masses of the lightest particles we find a somewhat irregular pattern, which cannot be fitted using a curve with a monotonous derivative. However, if we separate the particles into Mesons and Baryons we find that there is a good fit in both cases using the predicted mass curve (11), where we use spin s instead of the moments ratio σ, since s = σ cos(θ) and θ is always very small. Next we take the second lightest particles and fit them with the mass curve (11), omitting those which are too heavy to fit the curve. We take the leftover particles, add to them the next lightest particles from the remaining spins and repeat the process. The result is shown in figures 2 and 3.

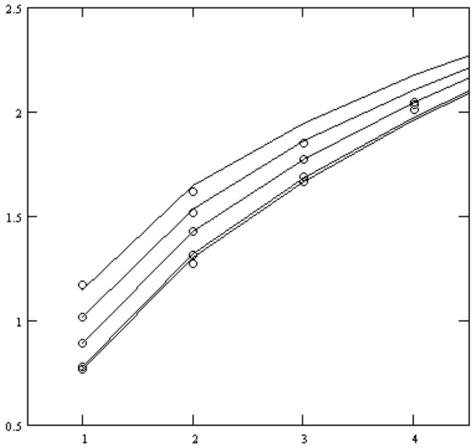

Figure 2. Mesons, spin v mass GeV.

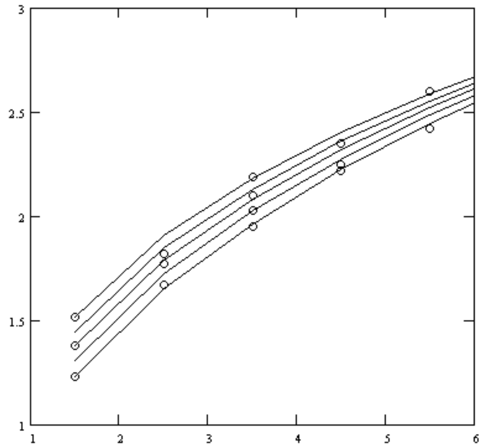

Figure 3. Baryons, spin v mass GeV.

In each instance the heaviest particle in a lower spin is lighter than the lightest particle in a higher spin. Thus, the particles are divided into horizontal bands and there is a clear tendency for the mass to increase with the spin. If we retain the same number of particles for each spin but re-distribute the mass at random this pattern is lost, as shown in figures 4 and 5.

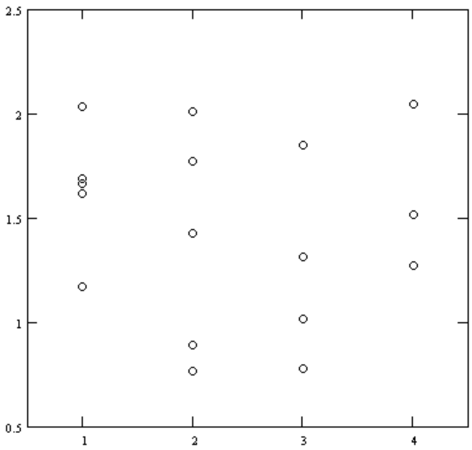

Figure 4. Mesons, random mass GeV.

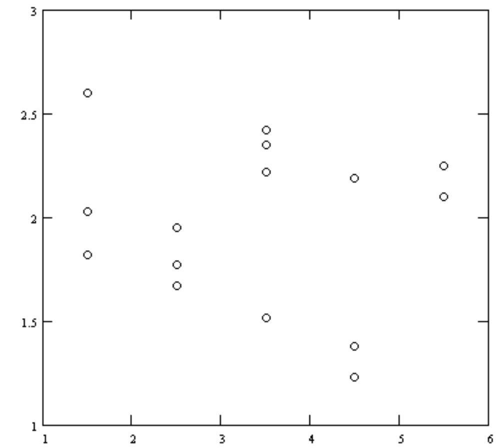

Figure 5. Baryons, random mass GeV.

With randomly distributed mass there is no way to fit the predicted mass curves (11). Thus, the mass curves do not fit the actual data just by chance. We use figures 2 and 3 to produce two periodic tables, table 1 for Mesons and table 2 for Baryons. The tables are similar in nature to the Mendeleyev Periodic Table of Elements, but our rows correspond to Virs, i.e. mass graph lines, and columns to spin. Some cells are empty and await the discovery of new particles. Other cells have two or three occupants, usually charged and uncharged varieties, which have slightly different mass, reminiscent of isotopes. Second and third cell entries are in sub-rows “a” and “b”.

Table 1. Periodic table of Mesons.

	Spin 1	Spin 2	Spin 3	Spin 4
Row 1	$\rho(770)^{+--}$h	$f_2(1270)$	$\omega_3(1670)$	$a_4(2040)$
Row 2	$\omega(782)$	$a_2(1320)$	$\rho_3(1690)$	$f_4(2050)$
Row 3	$K^*(892)^{+--}$	$K_2^*(1430)^{+--}$	$K_3^*(1780)$	$K_4^*(2045)$
Row 3a	$K^*(892)^0$	$K_2^*(1430)^0$		
Row 4	$\phi(1020)$	$f'_2(1525)$	$\phi_3(1850)$	
Row 5	$h_1(1170)$	$\eta_2(1645)$		

Table 2. Periodic table of Baryons.

	Spin 1.5	Spin 2.5	Spin 3.5	Spin 4.5	Spin 5.5
Row 1	Δ(1232)	N(1675)	Δ(1950)	N(2220)	Δ(2420)
Row 1a		N(1680)			
Row 2			Σ(2030)	N(2250)	
Row 3	$\Sigma(1385)^+$	Σ(1775)	Λ(2100)		
Row 3a	$\Sigma(1385)^0$				
Row 3b	$\Sigma(1385)^{--}$				
Row 4		Λ(1820)		Λ(2350)	
Row 5	N(1520)		N(2190)		N(2600)
Row 5a	Λ(1520)				

When we assign particle names to the dots on the graphs we find that the lines tend to group similar particles together. The most startling example is the third Meson line which consists entirely of Strange Kaons. The line fits these particles so well that the biggest prediction error is 0.38 of the measurement error (i.e. 0.15%) and the average error is only 0.18 (i.e. 0.07%). This degree of accuracy cannot be the result of chance.

We cannot test the theory on a larger number of particles because we have exhausted all particles with spin 3 or higher. In PDG Particle Listings (2004) [6] there are additional particles with spin 3 and higher, but they do not have sufficiently reliable data for inclusion in PDG Summary Tables [5]. There are 4 Baryons in the 1 star category (only one reported sighting) and 6 in the 2 star category. Mesons are not assigned stars, but also seem to be divided into two categories of reliability. The most unreliable are labelled “Further States” with 25 Light Unflavoured Mesons and the next category has a further 10 Mesons. Altogether there are 45 additional particles.

The additional particles extend the spin range for Mesons to 7 and Baryons to 7.5. There are 2 Baryons and 11 Mesons above the lines shown in figures 2 and 3. However, none of the additional particles is below these lines, which again indicates that Vir theory works well.

10. Accuracy of mass predictions

To judge the accuracy of the mass predictions we need to take three main factors into account. First, we used spin s instead of the moments ratio σ, since $s = \sigma \cos(\theta)$ and θ is always small. Second, the theory has no explanation of the electric charge and its influence on the mass. Therefore some degree of inaccuracy will be expected for the particles which have charged varieties and the measurements have not been accurate enough to assign them separate masses, instead one overall average is used. Where such separation has been achieved, as in the case of Strange Kaons, the accuracy of prediction increases.

Third, there have been very few new mass measurements carried out between 1995 and 2004 on the particles involved that were used by PDG to estimate their mass [6]. In particular, there have been no measurements at all on Baryons and only 33 on Mesons. However, only seven Mesons $f_2(1270)$, $\eta_2(1645)$, $a_4(2040)$, $f_4(2050)$, $a_2(1320)$, $\omega(782)$, $\phi(1020)$ had more than one measurement. In these seven cases the mass estimates have been revised quite dramatically. Thus, some predictions with the measurement error of 1.0 in 2004 could have had back in 1995 measurement errors of 7.9, 6.3, 2.2, 1.9, 1.5, 1.4 and 0.3 respectively. We must bear this in mind when judging how well our predictions match the experimental data.

Table 3 shows that most prediction errors are much less than 8 measurement errors, with the exception of $f_2(1270)$ which has mass estimate 1.275GeV and prediction 1.303GeV, resulting in the prediction error of 23 measurement errors. However, even this discrepancy may not be too excessive because one of the measurements, respectable enough to be listed in [6], by [BINON 83] gives the mass of 1.284GeV with the error of 0.030GeV, so that the estimated mass deviates from the prediction by less than one measurement error.

Table 3. Prediction errors for Mesons, in measurement errors, at parameters μ, β.

	Spin 1	Spin 2	Spin 3	Spin 4	μ	β
Row 1	0.00	23.04	0.17	-4.00	0.7665	0.4830
Row 2	0.09	2.01	-3.10	-5.44	0.7826	0.4755
Row 3	0.00	0.06	-0.38	0.28	0.89166	0.4272
Row 3a	0.00	-1.15			0.89610	0.4260
Row 4	-0.30	7.19	0.94		1.01945	0.3738
Row 5	-1.00	6.34			1.1500	0.3279

Table 4. Prediction errors for Baryons, in measurement errors, at parameters μ, β.

	Spin 1.5	Spin 2.5	Spin 3.5	Spin 4.5	Spin 5.5	μ	β
Row 1	0.00	-3.96	1.73	0.04	0.32	0.917	0.426
Row 1a		0.00				0.921	0.425
Row 2			0.01	0.44		0.995	0.398
Row 3	-0.08	3.40	-1.46			1.067	0.374
Row 3a	0.01					1.068	0.373
Row 3b	-0.01					1.072	0.372
Row 4		5.65		0.53		1.133	0.353
Row 5	0.08		-0.03		-0.18	1.209	0.331
Row 5a	0.03					1.208	0.331

11. Accuracy of lifetime predictions

We shall now test the accuracy of predictions of the full width Γ formula (55) using data from PDG Summary Tables (2004) [5]. Again we use s instead of σ. Figures 6 and 7 show how the width depends on the spin, with a separate graph for each row in the periodic table of particles.

We recollect that formula (55) does not apply to spin 1. We see that in each row the width estimated by experiments increases with the spin. There is just one exception, in the first Meson row where $\omega_3(1670)$ is below $f_2(1270)$. The width for $\omega_3(1670)$ is estimated at 0.168GeV, while the prediction is 0.24GeV. However, this is not an excessive departure because one of the measurements used by PDG to estimate the width, namely [CORDEN 78B], gives the width of 0.253GeV with the error of 0.039GeV, which is even higher than the predicted width.

The next biggest departure from the theoretical line is in the 3rd Baryons row for Σ(1775) spin 5/2. This seems to be caused by the low estimate for $\Sigma(1385)^+$ spin 3/2 which may be too low, because there are measurements for $\Sigma(1385)^-$ in PDG Particle Listings [6] by [ELY 61] and [COOPER 64] of 0.066GeV and 0.088GeV. With these width estimates we could fit the dotted line shown in figure 7. At the other extreme the third Meson row consists of Strange Kaons where all width estimates depart from the theory by less than 0.2 measurement errors, which is a remarkable fit.

The slope for each row is different and thus if we were to keep the particles within their columns, but redistributed them at random between rows we would not get them in ascending order of their width, let alone so close to their theoretical values. The particles were arranged into rows by the principle of least action. This resulted in such groups of particles that within each row mass increases with spin. Now we see that within each row also width increases with spin.

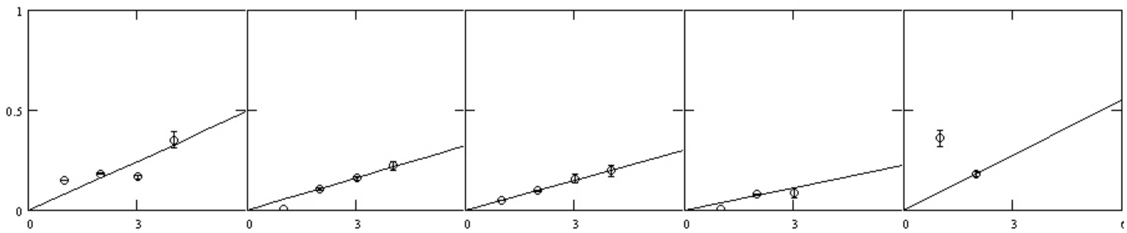

Figure 6. Mesons, spin v width in GeV.

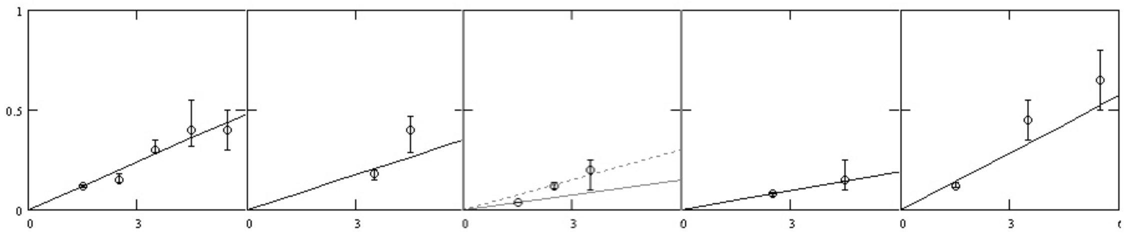

Figure 7. Baryons, spin v width in GeV.

Even more remarkable is that having chosen the slopes of the lines so as to provide the best data fit we find that for the corresponding Meson and Baryon rows the slopes are almost identical. If the theory did not reflect nature it would be most unlikely that such coincidences would happen.

The estimated PDG values for the Γ width are shown in figures 5 and 6, while the γ factor for each row and the resulting discrepancies with the theory are shown in figures 7 and 8. We notice large discrepancies for spin 1 particles, which is another confirmation that Vir theory works well.

Table 5. Estimated width for Mesons, in GeV.

	Spin 1	Spin 2	Spin 3	Spin 4
Row 1	0.1502	0.1843	0.168	0.353
Row 2	0.00849	0.107	0.161	0.222
Row 3	0.0508	0.0985	0.159	0.198
Row 3a	0.0507	0.109		
Row 4	0.00426	0.080	0.087	
Row 5	0.360	0.181		

Table 6. Estimated width for Baryons, in GeV.

	Spin 1.5	Spin 2.5	Spin 3.5	Spin 4.5	Spin 5.5
Row 1	0.12	0.15	0.30	0.40	0.40
Row 1a		0.13			
Row 2			0.18	0.40	
Row 3	0.036	0.12	0.20		
Row 3a	0.036				
Row 3b	0.039				
Row 4		0.08		0.15	
Row 5	0.12		0.45		0.65
Row 5a	0.016				

Table 7. Prediction errors for Mesons, in measurement errors, at parameter γ.

	Spin 1	Spin 2	Spin 3	Spin 4	γ
Row 1	-28.42	-7.81	7.80	-0.62	0.082
Row 2	568.88	0.20	0.10	-0.32	0.054
Row 3	-0.56	0.72	-0.39	0.11	0.050
Row 3a	0.00	-1.52			0.051
Row 4	674.80	-1.00	0.96		0.038
Row 5	-6.70	0.27			0.092

Table 8. Prediction errors for Baryons, in measurement errors, at parameter γ.

	Spin 1.5	Spin 2.5	Spin 3.5	Spin 4.5	Spin 5.5	γ
Row 1	0.00	1.67	-2.00	-0.50	0.40	0.080
Row 1a		0.00				0.052
Row 2			1.32	-1.22		0.059
Row 3	2.13	-3.83	-1.13			0.025
Row 3a	0.00					0.024
Row 3b	0.00					0.026
Row 4		0.00		-0.12		0.032
Row 5	1.50		-1.17		-0.85	0.095
Row 5a	0.00					0.010

12. Results and discussion

We started by assuming that particles are vortices of such shape that offer least resistance to spinning. From this we obtained two shapes of particles which we call a Spindle Vir (1) and a Spool Vir (2). Then, assuming that the mass of a particle is proportional to the volume of the Vir eye (with some universal space density constant ǥ), we obtained formula (11) for mass, where σ is the ratio of the moments of inertia, μ and β are constants for the Vir.

(11) $$m = \mu(2\sigma - 1)^{\beta}$$

Next we used Euler's equations of motion to show that an almost vertical symmetrical top returns to its initial state on completion of each precession if σ is almost an integer, and on every other precession if σ is almost a half integer. We extended the principle of least action by requiring that the body with least resistance to spinning must spin at the highest angular velocity relative to its precession. This results in an integer or a half integer ratio of rotation to precession, i.e. spin.

(32) $$s = \frac{\Omega_z}{\Omega_{\mathrm{Pr}}} = \frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, etc...$$

Again using Euler's equations of motion we showed that a slightly asymmetrical and almost vertical vortex results in a circular wave where the head is chasing its tail so that after a while a particle destroys itself via self-interference. With the help of the Quantum Mechanical requirement Mz = $\hbar \cdot$s we then derived the expression for the lifetime of such a wave. Using the Uncertainty Principle $\Gamma \cdot \tau = \hbar$ gave us formula (55) for Γ, where γ is a constant for a Vir.

(55) $$\Gamma = \gamma \cdot \sigma \qquad s \neq 1$$

For practical calculations we used s instead of σ, because s = σ cos(θ) and θ is always very small. We used (11) to construct two Periodic Tables of Particles, one for Mesons and one for Baryons, tables 1 and 2. Particles belonging to the same Vir, with masses on the same curve as shown in figures 2 and 3, are in the same row. Particles with the same spin are in the same column. The rows tend to contain similar particles, thus the third Meson row consists of Strange Kaons.

The data agree with formulae (11) and (55) remarkably well, thus for Strange Kaons all mass prediction errors are less than 0.4 of the measurement errors and all width prediction errors are less than 0.2 of the measurement errors. Remarkably, we find that the lines with the best data fit have virtually the same constant γ for the corresponding Meson and Baryon rows, figures 6 and 7. This is extremely unlikely to happen by accident and indicates that the theory reflects nature.

We can explain why the corresponding Meson and Baryon rows have the same constant γ by assuming that the corresponding Virs have the same elliptical eccentricity. It is possible to show that a Spool Vir can generate only Mesons, but we have no room for it here. The data imply that a Spindle Vir does not generate Mesons. It seems that Spools are Mesons and Spindles Baryons.

Finally, we outlined the way in which the theory may be extended to include all particles, not only those considered in this article. The theory does not touch the subject of electrical charges, but it is felt that they may be connected with rotation in the planes which involve the time axis.

13. Conclusion

Vir theory constructs a Periodic Table of Particles which provides a simple way of determining spin, mass, and lifetime of particles. Spin s is given by the column of the particle, mass by $m = \mu(2s-1)^{\beta}$ ($s > ½$) and width by $\Gamma = \gamma s$ ($s > 1$) where μ, β and γ are constants, different for each row. An outline is given how to extend the theory to particles with no mass and those with 0 or ½ spin.

The accuracy of predictions is remarkable, for example, in the third Meson row both mass and width are predicted with accuracy that is well within ½ measurement errors given in the PDG Particles Summary [5]. Where predictions are not quite as accurate as this, we can always find at least one measurement in the PDG Particle Listings [6] that make the predicted value plausible.

Particles are placed in the table on the basis of the Principle of Least Action, taking into account only their mass and spin. Yet we find that this process results in separating Mesons from Baryons. We also find that rows contain particles of similar properties, for example, the third Meson row consists entirely of Strange Kaons. We find that within a row the Γ width is proportional to spin, except for particles with spin 1, which is in full agreement with the predictions of the theory. Further, corresponding Meson and Baryon rows have the same slope γ, as shown in figure 8, where Mesons are above Baryons, with a graph for each row. Figure 9 plots the same data, but with particles placed in the table at random, resulting in chaos. Vir theory creates order out of chaos, replaces complexity by simplicity and I propose it does so because this is how nature is.

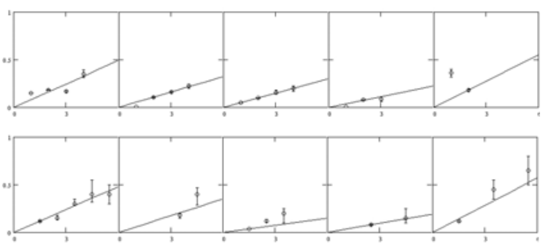

Figure 8. Width for the Periodic Table

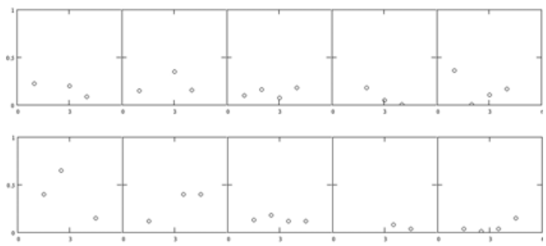

Figure 9. Width for a random table

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