The physical nature of the basic concepts of physics

Part 11. Mass [(i)]

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Abstract

In his paper Part 8 on the physical nature of velocity, the author has demonstrated that the fact that the size of a particle system is the area that is repetitively covered by the motions of its basic components, leads in a natural way to the Lorentz-Fitzgerald contraction of a moving particle system, which means that the so-called length 'contraction' is a real, physical compression in its direction of motion.
This allows the author to demonstrate in this paper that the force that we have to exert on a mass particle system to increase its velocity, is in fact the force that we must exert on it to compress it in its direction of motion.
It follows from this that, when a 3-dimensional mass particle system reaches the speed of light, it will have been compressed into a 2-dimensional particle system that moves with an invariable speed and that has variable motion and mass behavior (such as linear momentum and gravitational interaction) in a plane perpendicular to its invariable speed.
This means that the inertial 'mass' of a particle system is an emergent property that finds its origin in the 3-dimensional cyclic motion of its massless components, which leads in a self-evident way to Einstein's mass-energy equivalence, and allows the author to give the physical meaning of the Compton and the de Broglie wavelengths and of Planck's constant, and will in his next paper lead to a quantum theory on gravitation.

1. The indistinct nature of the present concept of 'mass'

Physics has always had difficulties in defining 'mass'. The present textbooks of physics give purely mathematical definitions of different sorts of mass (such as inertial mass, gravitational mass, rest mass and the mass-energy equivalence), but they don't tell us what makes a particle system massive, such as why electrons, protons or neutrons have mass and photons don't?

Newton defined 'mass' as "the quantity of matter", which is in fact nothing else than an expression of mass as "the total number of the particles with unit mass".
In the present physics, this numerical concept of mass is still used in the expression of the 'mass number' of atoms (A), which is the sum of the number of neutrons (N) and the atomic number of protons (Z): $A = N + Z$.
The atomic mass unit (u) is used for the expression of masses of atoms and molecules and is defined in a way that a single carbon-12 atom has a mass of 12u, which means

(i) Updated edition of the paper "Velocity, Mass and Time" April 1991 by the same author.

that: $u = 1.66054 \times 10^{-27}$ kg.
Because of Einstein's "mass-energy equivalence", the electron volt (eV) is also commonly used as a mass unit, which is expressed in (M)eV/c² or simply in (M)eV, where: $1\ MeV/c^2 = 1.78268 \times 10^{-30}$ kg

Newton's second law of motion, which establishes the relationship between mass, 'force' and 'acceleration', is the only law that gives a conceptual definition of the inertial mass of a body, as the resistance to changes of its velocity: $m = F/a$
It is on this basis that Ernst Mach proposed a procedure to measure an unknown mass [1].
In that procedure an unknown mass 'm' and a standard 'unit' mass 'm_s' exert forces on each other. The forces acting on these two masses are then, according to Newton's second law, of equal magnitudes and of opposite direction, so that:
$F = m.a = F_s = m_s a_s$
In that way the unknown inertial mass can be expressed in function of the standard mass: $m = m_s a_s/a$.
But it is clear that this is a comparative procedure that doesn't tell us what mass is and why some particles (e.g. Baryons) have 'mass' and other (e.g. photons) don't.

Experiments have shown that the "inertial mass" of a body (which is its acceleration due to an external force) is equal to its gravitational mass (which is its acceleration due to gravitational interaction). This makes it possible to measure the mass of objects directly by means of a simple balance, instead of the more complicated Mach procedure.

2. Einstein's mass-energy relation

Newton's concept of mass as "the quantity of matter" was okay for relatively low speeds. But it has been demonstrated that the mass of particles increases with their velocity: $m_v = m_0/\sqrt{1 - v^2/c^2}$
For $v \approx c$, it even increases to infinity!

In Einstein's Special theory of Relativity, mass is seen as a form of energy ($m = E/c^2$), in addition of the other forms of energy, such as 'kinetic' and 'potential' energy, and in his General theory of Relativity, gravitational acceleration is no longer caused by a pulling 'force', but it is the consequence a "curvature" of space-time, by which masses accelerate effortlessly to each other.

This demonstrates that in the present textbooks of physics, it is not clear what 'mass' is and what causes it. We can only conclude that the mass of an object is not only related to the force necessary to change its velocity (Newton), but that it is also related to its speed as such (Lorentz' mass increase) and that it modifies the motion of other masses by means of their mutual gravitational interaction.

3. The Higgs mechanism for massive bosons

The mechanism for the generation of mass of bosons was already suggested in 1962 by Philip Anderson. In 1964, Englert, Brout, Higgs, Guralnick, Hagen and Kibble came nearly simultaneously with a theory, that is nowadays is called the 'Higgs mechanism'.
This theory was developed when it became clear that in the Standard Model for particles and forces, not only the electromagnetic gauge bosons (photons) but also the weak force

gauge bosons (the W & Z bosons) should have zero mass and an infinite range.
This was however in plain contradiction with the physical fact that the weak force (W & Z) bosons have a large mass (around 80 GeV/c²) and a short range!

According to Brian Cox and Jeff Forshaw [2]: "*They couldn't possibly have mass from the early beginning, because that would make the gauge symmetry inconsistent and would lead to nonsensical predictions … Abandoning gauge symmetry is not an option, because then the theory falls apart and stops making sense. This apparent impasse was solved by the Higgs mechanism, in which is supposed that we started with a universe in which mass simply didn't exist and everything moved around at the speed of light*" (ii)
But "t*hen at a lower temperature 'something' must have happened, so that various particles obtained mass and started to move at slower speeds*." That 'something' that is responsible for the origin of mass, is called the "Higgs mechanism", in which the different masses of the bosons are generated out of the original massless particles, as a result of different interactions with a background Higgs field".
According to the Standard Model, the Higgs field exist throughout space and breaks the symmetry of the electroweak interaction, which allows the gauge bosons of the weak force to obtain mass characteristics, such as variable velocity.
The potential energy for the Higgs field (the "Higgs potential") has a non-zero energy in its ground state that looks like a Mexican hat. Just like the electromagnetic field is associated with the electron, the Higgs field is associated with the Higgs particle and the Higgs field has been proven to exist by detecting the Higgs boson. In that way, the Higgs boson has become the Standard Model's mechanism for mass generation.
All physicists agree that the benefit of the Higgs field is that it gives mass to the initially massless particles of the Standard Model, without spoiling the gauge symmetry" (iii).

4. The massless origin of mass particles

From the former section we can conclude that the universe has started with massless particles.
Although the actual processes at the first moments of the Big Bang are not exactly known, the present view of the Standard Model on the massless beginning of the universe, fully complies with that description of the early universe [3] "*In the beginning, the universe was dominated by* ***energy*** *at negative pressure, which led to an early exponentially accelerated expansion, referred to as inflation. ... Following that brief but extremely rapid inflation, the universe was first dominated by radiation and then subsequently by matter*" and [4] "*The original universe was a very small roll pure concentrated energy*".

Yet another argument in favor of the massless built up of mass particles, is given by the escape velocity of black holes. The escape velocity of a celestial body (wit radius R and mass M) is equal and opposite to the impact velocity of an object that is initially at rest ($v_i = 0$) at a very large distance ($r_i = \infty$) and that falls toward that celestial body.
It follows from this that the total initial energy of such an object at a very large distance from an attracting body is zero: $mv_i^2/2 + (- GMm/r_i) = 0$
and remains zero at all distances (r) (iv).

(ii) Which means that everything was light!
(iii) The Higgs mechanism doesn't however explain the gravitational properties of the acquired masses.
(iv) The physical nature of 'potential' energy is analyzed in my paper "Potential Energy".

So, when that falling object reaches the surface of the celestial body (r = R), the impact velocity is: $v_{esc} \geq \sqrt{2GM/R}$.
When that celestial body is a black hole, the impact velocity as well as the escape velocity will both be equal to the speed of light ($v_{esc} = c$). This means that the radius (R) of the black hole must be: $R \leq 2GM/c^2$.
Since only massless particles can travel at the speed of light, this logically means that while accelerating to a black hole, the falling masses must gradually disassemble into their massless components in order to be able to move at the speed of light!

5. The vagueness of the present Higgs mechanism

Lisa Randall seems rather skeptical about the Higgs mechanism when she writes that [5]: "*The Higgs boson is part of a very particular implementation, which only further data will definitely confirm or rule out*". .. *Such an elementary particle mass relies on the existence of what particle physicists call a 'field' - a quantity that exists throughout space, but that doesn't necessarily involve any actual particles*" and she concludes that "*The concept of a field is a bit esoteric and confusing, especially as the word field outside of physics conjures images of cows grazing*".
According to Lisa Randall [6] "*The Higgs field is a quantity that permeates the vacuum and has a nonzero value. A nonzero value for a field is something special. If a field carries charge, it means that charge can disappear in the vacuum, so the charge won't be conserved. If the particle that is created by the field has nonzero spin, the rotational symmetry would be broken as well*."
And further "*According to the calculations, fundamental scalars should be extremely heavy – sixteen orders of magnitude heavier than the boson that has been measured*. .. *Without additional underlying physics, a light fundamental scalar is an enormous fudge ...The Higgs mechanism certainly addresses one mystery – how elementary particles acquire their mass – but still leaves open the question why those masses are what they are."* From this we must conclude that the Higgs mechanism gives a simple solution to the origin of mass in the universe, but creates a lot of questions that can only be answered if we know the true meaning of all the other fundamental concept of physics.
It is thereby so that the Higgs mechanism establishes the relation between mass and the Higgs field, but it doesn't tell us anything about the specific constitution of mass particles as such.

6. The absence of 'mass increase' in Special Relativity

In section 1 of my paper part 7 on the physical nature of velocity, I have demonstrated that from his assumption of a deformable electron and his transformation equations, Hendrik Lorentz came to an expression for the physical connection between the velocity increase and the mass increase of moving electrons in their direction of motion:

$$m_v = \frac{m0}{\sqrt{1 - v^2/c^2}} = \gamma m_0$$

Lorentz had come to this expression on the assumption that electrons suffer a physical length contraction in their direction of motion [7].

In his book "Über die spezielle und die allgemeine Relativitätstheorie" [8] Einstein writes that there is no proof for that hypothesis, and he was even opposed to the use of the term "relativistic" mass or even a symbol for it. In a letter to a colleague in 1948 he wrote [9]:

"It is not good to introduce the concept of mass $M = m/(1-v^2/c^2)^{1/2}$ *of a body for which no clear definition can be given. It is better to introduce no other mass than "the rest mass" m* [(v)] *and instead of introducing M, it is better to mention the expression for the momentum and energy of a body in motion."*

So Einstein replaced Lorentz' relativistic mass by his own relativistic equations of:

- relativistic momentum: $\mathbf{p} = \gamma(v)m\mathbf{v} = \frac{m\boldsymbol{v}}{\sqrt{1-v^2/c^2}}$
- relativistic kinetic energy: $E_K = [\gamma(v) - 1]\,mc^2 = mc^2\,(\frac{1}{\sqrt{1-v^2/c^2}} - 1)$

which are more linked to velocity and which were already in Newtonian physics considered as relative data.

In that way the total relativistic energy of a mass moving at a velocity 'v' is:

$E = \gamma(v)mc^2 = \frac{mc^2}{\sqrt{1-v^2/c^2}}$

For v = 0 this last equation automatically leads to Einstein's famous mass-energy equation for the so-called "rest" mass of a mass particle: $E = mc^2$

In Einstein's Special Theory of Relativity, velocity is a purely relative characteristic of which the numerical value is determined by any (arbitrarily) chosen reference frame (which is also the case for its derived characteristics, such as 'linear momentum' and 'kinetic energy'). It was thereby considered a reassuring factor of his Special Theory of Relativity, that despite the fact that observers in different inertial reference frames would disagree about the values of these fundamental characteristics, they all would agree that their numerical values are conserved in physical interactions, so that the conservation laws would remain valid in all relativistic reference frames.

Lorentz however never changed his mind about the physical nature of the length contraction. Shortly before his death he wrote [10]: *"I should like to emphasize the fact that the variations of length caused by a translation, are real phenomena, no less than* for instance, the variations that are produced by changes of temperature".

According to Stanley Goldberg this complete difference of opinion between Lorentz and Einstein's view on the length contraction didn't much trouble the physicists of that time [11]: *"In the minds of many, since the predictions of Einstein and Lorentz were the same, they were seen as aspects of the same theory. Even supporters of Einstein shared this confusion: for example, Max Planck referred to the Lorentz-Einstein theory and Hermann Minkowski, the man who is credited with generalizing Einstein's theory to four dimensions, remarked that Einstein's work was a generalization of Lorentz's".*

7. The physical connection between length contraction and mass increase

7.1 Mass increase with velocity

Lorentz' expression for the mass of a body with a rest mass 'm_0' that is moving with a velocity 'v' is: $m_v = m_0\sqrt{1 - v^2/c^2} = \gamma m_0$

I my paper Part 8 on the physical nature of velocity, I have demonstrated that this mass increase can also be expressed in function of the angle of rectification 'α' (by which γ = sec α): $m_v = m_0/\sqrt{1 - sin^2\,\alpha}$

In that way the mass increase with increasing velocity, can be expressed as:

$\Delta m = m_v - m_0 = \gamma m_0 - m_0 = m_0(\gamma - 1)$

(v) If mass doesn't change with velocity, it is at least peculiar that Einstein used the term "rest" mass.

This also means that mass increases with temperature (because temperature is a function of the internal speed of the particles of a particle system) and that mass increases when a spring is compressed, because in my paper on potential energy fields, I have demonstrated that potential energy of a particle system is a mathematical expression of its internal (rotational) motion (the flywheel model).

7.2 Momentum increase with velocity

The linear momentum of a mass moving with a velocity 'v' is: $p_v = m_v v$
This linear momentum can be expressed in function of its rest mass m_0 as:
$p_v = m_v.v = \gamma m_0.v$
The momentum increase is then:
$\Delta p = m_v.v - m_0.v = (m_v - m_0)v = \Delta m.v = m_0 v(\gamma - 1)$
This demonstrates that Einstein's 'relativistic' momentum increase is a direct consequence of the physical mass increase 'Δm' of the moving body.

7.3 Energy increase with velocity

The energy content of a mass that is moving with a velocity 'v' is:
$E_v = m_v.c^2 = m_0c^2(1-v^2/c^2)^{-1/2} = \gamma m_0c^2$
The energy increase with velocity is then:
$\Delta E = (m_v - m_0)c^2 = \Delta m.c^2$
This demonstrates that also Einstein's 'relativistic' energy increase is a direct consequence of the physical mass increase 'Δm' of a moving body.

This 'relativistic' energy increase ΔE is nothing else than the kinetic energy K of the moving body: $\Delta E = K = (m_v - m_0)c^2 = \Delta m.c^2$
So that: $m_vc^2 = K + m_0c^2$
which, since $m_vc^2 = E_v$
gives: $E_v = K + m_0c^2 = m_0c^2(\gamma - 1) + m_0c^2 = \gamma m_0c^2$
This equation is in its general form, known as the mass- energy equivalence:
$E = m_0c^2 + K$
In this equation m_0c^2 is the internal kinetic energy of the rest mass, which is a mathematical expression of the kinetic energy of m_0 unit mass particles that move about each other at the speed of light.
For v << c: the MacLauren series expansion $\gamma = 1/(1 - v^2/c^2) = 1 + v^2/2c^2$
So that: $\Delta E = K = \Delta m.c^2 = (mv - m_0)c^2 = m_0c^2(\gamma - 1) = m_0c^2 [(1 + v^2/2c^2) - 1]$
Or: $K = m_0v^2/2$
So that the total energy for low speeds is given by: **$E = m_0c^2 + m_0v^2/2$**

7.4 The energy momentum relation

The difference of the square of the total kinetic energy E^2 and the squared product of the relativistic momentum p_v times the speed of light c, is then:
$E^2 - p_v^2c^2 = (\gamma m_0c^2)^2 - (\gamma m_0vc)^2 = (\gamma m_0c)^2(1 - v^2/c^2) = (m_0c^{2)2}$
So that: $E^2 = (p_vc)^2 + (m_0c^2)^2$
Or: **$(mc^2)^2 = E^2 - (pc)^2$**

Which is Einstein's energy- momentum equation.

8. The physical nature of the velocity of particle systems

8.1 Mass and variable velocity as the result of symmetric rotations

In sections 4.1 and 4.2 of my paper Part 8 on the physical nature of velocity, I have demonstrated that the bare fact that mass particles have a upper speed limit that is identical to the (invariable) speed of massless particles, indicates that elementary mass particles are particle systems that are built up from massless components.
And in section 4.4 of that same paper, I have demonstrated that elementary mass particles with variable velocity don't behave as monolithic bodies, but as 3-dimensional particle systems, that consist of (2-dimensional) massless components, moving about each other at the speed of massless particles.
In that way, the degree of coherence/entanglement of the internal motions of its massless components can be represented as a complex number:

- in which the real component 'v' indicates the congruent velocity with which the particle system moves as a whole in a given (x-)direction, and
- in which the imaginary component 'q' indicates the internal RMS-speed 'q' in all three directions.

This allowed me to define the velocity of a mass particle system as the degree of 'coherence', 'congruence or 'rectification' of the velocities of its basic massless components, as the sine of their angle of rectification (α): $v/c = \sin \alpha$.

- If α is 0°, $\sin \alpha = 0$ and $v = 0$ and there is only isotropic motion
- If α is 90°, $\sin \alpha = 1$ and $v = c$ and all motion is rectified into congruent motion.

This can be represented in a 2-dimensional figure (Fig. 11.1):

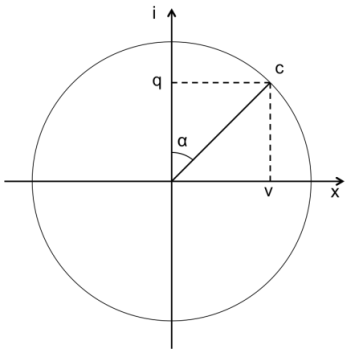

Fig. 11.1

In that way the total kinetic energy of a particle with mass 'm' is equal to:
$mv^2 + mq^2 = mc^2$
or: $v^2 + q^2 = c^2$
or $(v^2/c^2) + (q^2/c^2) = 1$
and $\sin^2 \alpha + \cos^2 \alpha = 1$
In which: $v = c.\sin \alpha$ and $q = c.\cos \alpha$
This demonstrates that a particle system in which all particles have the same invariable speed 'c', can obtain an increasing velocity and consequently an increasing mass in a given (x) direction by means of an adiabatic expansion, that rectifies the motions of the

particles in that (x) direction. In other words, it can by a symmetric 3-dimentional rotation of the translational/rotational/vibrational motion of the basic particles into a given (x) direction [(vi)].

This view of the close relation between mass and velocity corresponds quite well to the present Higgs theory, in which in order for a scalar field to have a phase, it must be complex and it should contain two fields with a symmetry that rotates them into each other [12]. Due to these rotations the components of the SO(3) gauge field become massive vector mesons.
According to the Higgs mechanism for obtaining mass by means of a symmetric rotation, the most common processes for Higgs boson production are under others:

- Higgs Strahlung: In this case a quark collides with an anti-quark or an electron with a positron. The two can merge to form a virtual W or Z boson which, if carries sufficient energy, can then emit a Higgs boson. This process was the dominant production mode at the LEP, where an electron and a positron collided to form a virtual Z-boson.
- Weak boson fusion: When e.g. two fermions (e.g. an up quark and an anti-down quark) collide, the two exchange a virtual W or Z boson, which emits a Higgs boson.
- Top Fusion: This process involves two colliding gluons which each decay into a heavy quark-antiquark pair. A quark and an antiquark can combine to form a Higgs particle.

This means that in order to obtain a rotation into each other's direction, the field must consist of a particle anti-particle pair.

8.2 The mass increase with increasing velocity

In my paper Part 7 "The true nature of velocity" section 3.2, I have demonstrated that the fact that mass particles have an absolute, physical upper speed limit, that happens to be the invariable speed of massless 'particles', indicates once more that a speed increase of a mass particle system is obtained by a rectification of the isotropic internal motions (q = c) of its massless components, producing in that way congruent translational velocity (v) of the particle system as a whole [(vii)] .
This simply means that elementary particles with variable velocity, generally known as 'mass' particles, must be composite particle systems that consist of basic units of matter that move about each other at the invariable speed of light and that can vary their velocity from '0' to 'c' in function of their degree of rectification ($v = c \sin \alpha$)

This seems a daring conclusion, but it fits in with Einstein's mass-energy relation $E = mc^2$, which is in fact a mathematical expression of the kinetic energy of 'm' particles with unit mass that move in a congruent way at the invariable speed of light!
In that way a particle system that consist of unit components that all have the same invariable speed, can nevertheless change its congruent speed (v) from '0' to 'c', in function of the degree of rotation ($\sin\alpha = v/c = \beta$), of the motion of all its components in the same, given direction , which has led me to my universal speed equation: $v = c.\sin\alpha$.

In section 5 of that same paper part 7, I have thereby demonstrated that the 'size' or 'shape' of an observable 'particle' is the area that is repeatedly covered by the internal

[(vi)] The origin of the momentum and energy increase of massive bodies accelerating to each due to their gravitational interaction, will be analyzed in my paper on interactions at a distance.
[(vii)] See my paper Part 7 on the physical nature of velocity.

motions of its basic components, and which means that the size of such a particle system in a given direction, will be proportional to the value of their internal speed 'q' in that direction.
In that way the proportion of the size of such a particle system in its direction of motion to the size of the particle system at rest (l_v/l_0), will be equal to the proportion of the internal speed (q) in its direction of motion to the internal speed at rest (c):
$l_v/l_o = q/c = \cos\alpha = \sqrt{1-\sin^2\alpha} = \sqrt{1-v^2/c^2} = \sqrt{1-\beta^2}$
which is the equation of the 'Lorentz-Fitzgerald' contraction of a moving mass in function of its speed.

Since I derived this equation of the length contraction from the calculation of the area that is repeatedly covered by the repetitive motions of its elementary components, this variation of the size in the direction of motion is not an observation or a measurement problem, but it is a real physical distortion of the moving particle system: with a growing speed in a given direction, the isotropic motions of the basic components must be physically confined into an increasingly smaller area in that direction!

This means that the force that we have to exert on a mass particle system in order to increase its velocity in a given direction, is in fact the force that we must exert on it in order to compress the repetitive motions of its components into a smaller area, so that in fact we ought to speak of the Lorentz-Fitzgerald 'compression' rather than the 'contraction'.

This means that if the size in the direction of motion of a particle-system moving at a speed 'v' is 'l_v' and if this size is 'l_o' when at rest, then the degree of anisotropic compression can be expressed as: $F_v/F_o = l_o/l_v$
Which, since '$a = F_v/m_v = F_o/m_o$
So that: $F_v/F_o = m_v/m_o$ and: $m_v/m_o = \sqrt{1-sin^2\alpha}$
which since, $\sin\alpha = v/c$, leads to:

$$m_v = m_0 \frac{1}{\sqrt{1-v^2/c^2}} = \gamma m_0$$

Which is Lorentz' expression of the "mass increase".

In this equation, which in the words of Max Born [13] "*expresses how the mass depends on the velocity*", the constant 'm_0' represents the physical 'rest mass' of the particle system.
In that way: $m_v = \gamma m_0 = m_0/\sqrt{1-v^2/c^2} = m_0/\sqrt{1-sin^2\alpha} = m_0/\cos\alpha$
represents the mass of the particle system as it moves at a speed 'v'.

9. The 3-dimensional structure of 'mass' particles

In the former section I have demonstrated that the force, necessary to increase the speed of a mass particle system, is in fact the force to give it an anisotropic compression in that direction.
This means that a mass particle system must reach a maximum speed limit when this compression has reached its maximum value, or in other words, when its radius in the direction of coherent motion has become extremely small ($R_c = 0$). It follows however

from the physical nature of the Lorentz compression that the internal forces and therefore the mass in the direction of motion, will by then have reached an enormous amplitude: $m_c/m_o = F_c/F_o = R_o/R_c = l_o/l_c = 1/0 = \infty$

Contrary to the mathematical equations, the enormous effort that is necessary to induce this compression will not result in a particle-system with an infinitely great mass [(viii)], but in a particle system that, with increasing speed, becomes shorter in its direction of motion. This physical nature of the Lorentz contraction is demonstrated by the representation of the Lorentz contracted, high speed gold nuclei that move with velocities of 0,9999c [14] (Fig. 11.2).

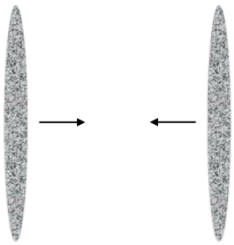

Fig. 11.2

In physical terms this means that when a mass 'particle' approaches the speed of light, its 3-dimensional vibrational/rotational internal motion will have been transformed in a flat 2-dimensional vibrational/rotational motion that stands perpendicular to its speed and that has no mass in its direction of congruent motion.
This description of flat 2-dimensional 'particles' that move with an invariable speed and that have harmonic internal rotational/vibrational motion and therefore mass-like behavior (such as linear momentum and gravitational interaction) in a plane perpendicular to their invariable speed, are generally known as "photons" and are generally represented as given in fig. 11.3 [15].

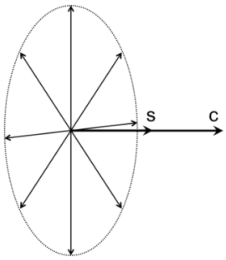

Fig. 11.3

This leads once again to the important conclusion that the basic 'mass particles', such as e.g. electrons, must in fact be 3-dimensional particle systems that are built up from 2-dimensional 'energy particles'.
This definition of 3-dimensional mass particles and 2-dimensional energy particles corresponds quite well to the mathematical concept of "symmetry breaking" [16] in which e.g. massive weak bosons are associated with waves that can oscillate in any three directions, whereas massless gauge bosons, such as photons that proceed at the speed of light, have only two polarizations. The third polarization, which is called the

(viii) Infinity is a purely mathematical concept, that has no physical meaning since it is in complete contradiction with all conservation laws.

longitudinal polarization because it oscillates along the direction of motion, doesn't exist in the case of massless photons. In that way it becomes obvious that the speed of a light beam that is sent from a light emitting source that moves with any given speed, cannot be affected by the motion of the source.

This conclusion that mass particles consist of massless particles, leads to a natural explanation of the 'mass-energy equivalence', which is one of the great discoveries of Albert Einstein in the early twentieth century.
A classic example of this is the case in which mass particles combine with their antiparticles. Antiparticles have the same mass and the same spin angular momentum as their counterpart particles, but they have opposite electric charge and opposite spin magnetic moments. In the typical case of the so-called 'annihilation' of an electron-positron pair [17] "*mass particles with equal masses 'm_e' are attracted to each other by their opposite electric charges and orbit around each other for a brief instance. Then the two unite, mutually annihilating and producing e.g. two photons*". If the speeds of the colliding mass particles is low compared to the speed of light, the energy of each mass particle can be expressed as "m_ec^2" so that the conservation of momentum and energy requires that the produced photons will move in opposite directions with energies equal to 'm_ec^2'.
In the reverse process, namely the 'creation' of mass particles from two photons, the energy needed to create a mass particle is provided by the internal vibrational/rotational motion of the photons.

10. The physical nature of mass

10.1 The physical nature of the rest mass

In section 4.3 "Mass particles as bound states of massless particles" of my paper Part 8 on the physical nature of velocity, I came to the conclusion that the permanent interchange between mass particles and massless photons as well as their common upper speed limit, strongly indicate that elementary mass particles consist of entangled photons.

In that same paper Part 7, I came to the conclusion that an accelerating mass particle system undergoes an increasing compression in its direction of motion, which is mathematically expressed as the proportion of its in its x-direction (of congruent motion), to its size in the perpendicular y- and z-directions:
$l_v/l_o = 1/\gamma = \sqrt{1 - v^2/c^2} = \cos\alpha$

In the former section I have demonstrated that consequently the 'inertial' mass, is in fact the 'force' that we have to exert on a particle system to give it a unit anisotropic compression in its direction of (congruent) motion. In section 5.2, this view has in a self-evident way, led to the equation of the mass increase of an object in function of the degree of 'rectification' of the motion of its basic components.

My clarification of the physical nature of 'velocity' has allowed me to reveal the relation between the mass increase and the length contraction for any given speed as:
$m_v/m_0 = l_0/l_v = \gamma = 1/\sqrt{1 - v^2/c^2}$

In section 5.2, I have demonstrated that in this equation, the length 'l_0' of a mass

'particle' represents in fact the diameter of the circular area that is repeatedly covered by the motion of its basic particles, when that mass 'particle' is at rest.
Since for spherical particles, this relation can also be expressed in function of the radius 'R' instead of the diameter (l =2R) as: $m_v/m_0 = R_0/R_v$
So that for fundamental mass particles: mR = a constant

In order to have an invariable intrinsic spin angular momentum, we will suppose that these fundamental mass particles consist of basic massless particles that rotate about each other at the invariable speed of light and create in that way a mass 'm', and we will see to what it leads us.
So their invariable angular momentum L becomes: $L = mRc$ = a constant.
Which for rotational motion, can be expressed as: $L = I\omega$

For rotating photons, considered as a thin hoop rotating about its diameter or as a cylinder rotating about its symmetry axis: $I = mR^2/2$
So that its invariant angular momentum can be expressed as: $L = I\omega = mR^2\omega/2$

This means that when photons with identical frequencies become entangled, they form a thin hoop that rotates with their common frequency $f = \omega/2\pi$.
The moment of inertia of such a rotating loop is: $I = mR^2/2$
So that the intrinsic spin angular momentum is consequently equal to:
$L = I\,\omega = mR^2\omega/2 = mRc/2$

The magnitude of the spin angular momentum of an electron is invariably equal to:
$L = mRc/2 = ½\, h/2\pi$ (= $0{,}5272858 \times 10^{-34}$ J.s).
So that: $mRc = h/2\pi$ = a constant.
In that way, the equation for the rest mass can be written as:

$$m_0 = h/2\pi R_0 c$$

Which demonstrates that the entangled photons that orbit about each other, produce a variable velocity in three directions and produce in that way the emergent characteristic that we call 'mass', of which the magnitude is inversely proportional to the radius of rotation of its 'massless' components. .

10.2 The mass increase with velocity

It follows from my mass equation that: $m_v = \gamma m_0 = \gamma(h/2\pi R_0 c) = h/2\pi R_v c$
This demonstrates that the mass increase of a mass particle from m_0 to m_v, is caused by the compression of that particle in its direction of motion:
$R_v = = R_0/\gamma = R_0\sqrt{1 - v^2/c^2}$

10.3 The wave equation of (inertial) mass

Since the angular velocity 'ω' of particles rotation about each other at the speed of light is equal to: $\omega = c/R = 2\pi f$
So that: $R = c/2\pi f$
The former mass equation of an orbital particle system can also be expressed in function of its wave characteristics as: $m_v = h2\pi f_v/2\pi c^2$, so that:

$$m_v = hf_v/c^2$$

which is Einstein's famous mass-energy equation coupled with Planck's energy equation of photons: $E = hf = mc^2 = K$

These equations confirm my view that Einstein's and Planck's equations are intrinsically based on the same particle model in which mass particles are 3-dimensional particle systems that are made up of 2-dimensional particles that orbit about each other with the invariable speed of light [(ix)].
When that mass particle (system) accelerates in a given direction, its internal, isotropic motion is gradually rectified into congruent motion in that direction, which reduced the dimension of the mass particle (system) in its direction of congruent motion.

10.4 The physical meaning of the Compton and the de Broglie wavelengths

In this paper I have demonstrated that the so-called "elementary" particles of matter such as electrons, quarks and even photons, are in fact composite particle systems that consist of massless particles that circulate about each other at the invariable speed of light and that they have an invariable spin angular momentum which is equal to 1or ½ times Planck's constant $h/2\pi$.
This viewpoint leads automatically to the equations of the Compton wavelength and the de Broglie wavelengths.
We will in a first instance consider the spin 1 particles (photons), so that:
$S = mRc = h/2\pi$
So that: $m = h/2\pi Rc$
Since for rotational motion: $\lambda = 2\pi R$
this means that: $m = h/\lambda c$
so that: $\lambda = h/mc = h/p$
This is the expression of the de Broglie wavelength.

For electrons, with a mass 'm_e' de Broglie's expression directly leads to the Compton wavelength of electrons: $\lambda = h/m_e c = 2.43 \times 10^{-12}$ m
This means that the Compton wavelength is equal to the de Broglie wavelength for electrons and that electrons correspond to my model of mass particle systems that consist of massless particles moving about each other at the invariable speed of light.
The equation of the Compton wavelength can therefore also be used to calculate the electrons' radius.
From the former equation: $m_0 = h/2\pi R_0 c$, we obtain:
$R_e = h/2\pi m_e c$
$R_e = 1.05457 \times 10^{-34}$ J.s/(9,1094 x 10^{-31} kg)(2.9979245 x 10^8 m/s)
$R_e = 3{,}8615792 \times 10^{-13}$ m
Which is exactly the radius of the reduced Compton wavelength for an electron.
The former equation of the Compton wavelength: $m = h/\lambda c$
leads us thereby automatically to the equation of the de Broglie wavelength
$p = mc = h/\lambda$

(ix) I will further analyze this equation in my paper "The true nature of energy particles".

11. The physical meaning of Planck's constant

In my paper Part 1 "The true nature of linear momentum", I have demonstrated that the 'linear' momentum of a particle system is a mathematical expression of its total amount of congruent translational motion, which means that the 'angular' momentum of a particle system is consequently a mathematical expression of its total amount of congruent 'rotational' motion.
From quantum mechanics we know that the fundamental subatomic particles have an invariable intrinsic spin angular momentum or shortly 'spin' ($h/2\pi$) which is equal to 1 (bosons, such as e.g. photons) or ½ (fermions, such as e.g. electrons or quarks) times '$h/2\pi$'.
If we take e.g. the case of bosons with a spin of 1, this means that the intrinsic angular momentum of e.g. photons in the direction perpendicular to their invariable speed is equal to: $S_B = h/2\pi = m_B R_B.c = mRc$

In my view, this means that e.g. photons are 2-dimensional particle systems that consist of basic unit particles that rotate with a radius 'R_B' about each other at the speed of light in a plane perpendicular to their propagation, and have an invariable angular momentum or in other words an invariable amount of internal rotational/vibrational motion, that is equal to '$h/2\pi$'. This means that the factor '$h/2\pi$' represents the invariable amount of internal congruent rotational/vibrational motion of a photon.
This allows us to reveal the real physical meaning of Planck's constant 'h' as:
$h = 2\pi S_B = m_B(2\pi R_B)c$

which means that for bosons, Planck's constant 'h' represents the total amount of congruent rotational motion per rotation (over 360°) and that for fermions with spin 1/2, the intrinsic angular momentum of e.g. electrons in the direction perpendicular to their variable speed is equal to: $S_F = (1/2)h/2\pi = h/4\pi = m_F R_F.c$
So that: $h = 4\pi S_F = 2m_F(2\pi R_F)c$

This means that for fermions, Planck's constant 'h' represents the total amount of congruent rotational motion per rotation over 720°:

This allows us also to reveal the physical meaning of Planck's energy equation: $E = hf$ as the mathematical expression of the total amount of rotational motion per rotation times the number of rotations per second, or in other words, as the mathematical expression of the total amount of (transferable) rotational motion per second.

12. The mass characteristics of photons

12.1 The gravitational deflection of light

In section 6 of my paper part 8 on the physical nature of velocity, I demonstrated that an accelerating mass particle undergoes a physical compression in its direction of motion, which is mathematically expressed as the proportion of the size of the mass particle in its (x-) direction of (congruent) motion, to its size in the orthogonal (y- and z--directions: $l_v/l_o = (1-v^2/c^2)^{1/2} = 1/\gamma$

It follows automatically from this equation, that when the speed in the x-direction of a

mass particle reaches the speed of light 'c', the internal isotropic motion and consequently the size 'l_v' of that mass particle in its direction of motion, will virtually have become zero. This means that we obtain a particle system that proceeds with the invariable speed of light and that has only internal repetitive vibrational-rotational motion in a plane that stands transversal on the direction of its invariable speed.

This phenomenon is identical to the view elaborated in the present quantum field theory with regard to the increasing speed of spin ½ fermions, such as electrons, neutrino's and quarks.
The angular momentum of quantum particles such as electrons, does not change in magnitude, but [18] "*appears to turn toward the direction of the velocity vector*". This means that quantum mechanically, at high speed a particle's angular momentum (spin) appears to realign itself closer to its translational velocity vector. So that, as the velocity of the electron approaches the speed of light, its angular momentum vector (spin) and its velocity vector will point exactly in the same direction.
This means that at the speed of light, mass particles are disassembled into their basic photons (x) of which the spin is always aligned with the velocity vector, either in the direction of its velocity (Fig. 7.7) or in the opposite direction.

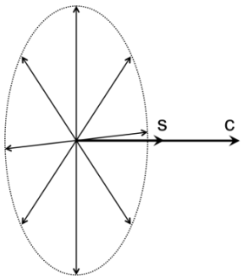

Fig. 10.4

The increasing contraction of an accelerating mass particle in its direction of motion, as represented in my figures 7.6 and Fig. 7.7, is explained in the same way by Jim Baggott in his presentation "The Concept of Mass" on YouTube [19].
In that presentation, Jim Baggott considers a steadily increasing mass particle that undergoes a seamless transition, from a spherical particle at standstill, to an ellipsoid at high speed and to a flat circle perpendicular to its velocity at the speed of light! Which logically means that photons have mass characteristics, such as gravitational attraction, in the plane perpendicular to their invariable speed (xi).

This confirms my conclusion at the end of sections 4.2 and 4.3, that mass particles are built up from massless particles and it demonstrates that whenever mass particles reach the speed of light, they simply become light!
And that is the real, physical explanation of Einstein's mass-energy equation for the rest mass: $E = m_0c^2$, which is in fact a demonstration of the fact that mass particles are built up from photons.

This allows us to conclude that mass particles are 3-dimensional multi particle systems that have mass and can vary their speed in all 3 directions and that they consist of entangled photons that are 2-dimensional particle systems that proceed at the invariable

(x) The concept of photons was introduced by Einstein in his paper on the photoelectric effect, for which he received the Nobel Prize in 1921.
(xi) This will be analyzed in my paper on the physical nature of mass.

speed of light and that have mass characteristics such as variable velocity and linear momentum, in directions perpendicular on their propagation.

This conclusion corresponds quit well with the present concept of weak force symmetry breaking, in which [20] weak gauge bosons have 3 polarizations and oscillate and have mass and variable speed, in all 3 directions.

It corresponds also with the fact that massless gauge bosons travel at the invariable speed of light and have only 2 polarizations, that oscillate in the directions perpendicular to their direction of propagation. The third polarization, which is called the longitudinal polarization because it oscillates along the direction of motion and which produces variable velocity, doesn't exist in the case of massless particles such as photons.
In that way, the apparent 'mystery', namely that the speed of a light beam that is sent from a light emitting source that moves with any given speed, cannot be affected by the motion of the source and cannot affect the motion of the receiver, becomes a self-evident conclusion.

It also explains the curved trajectory of light rays passing near the sun, by means of their transverse mass characteristics (xii) including gravitational interaction with other masses.

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(xii) The transverse mass characteristics of photons will be further analyzed in my papers on the physical nature of gravitation.

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