Novel Dynamics

by the Energy Circulation Theory

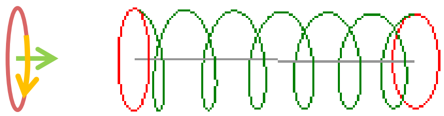
Elementary Energy Circulation

(Particle)

$$E_0 = m_0{\mu_0}^2{\omega_0}^2 = m_0c^2$$

Linear motion of particle

$$E = m\left({C_r}^2 + v^2\right) = m{\mu_0}^2\omega^2 + mv^2 = mc^2$$



Novel Equation of Motion

$$F = \frac{m}{1 - v^2/c^2}\alpha$$

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Novel dynamics by the energy circulation theory

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Chapter 1: Mass in the standard physics

1.1. What is the mass?

What is the mass? To this question, the most common answer would raise the three properties of mass; (1) resistance in being accelerated, (2) what causes the gravitational force, and (3) equivalence to energy. These properties are expressed by the following fundamental equations.

$$\mathbf{F} = m\boldsymbol{\alpha}\,, \qquad \boldsymbol{\alpha} = \frac{d\mathbf{v}}{dt} = \frac{d^2\mathbf{x}}{dt^2} \tag{1}$$

$$\mathbf{F} = G\frac{m_1 m_2}{d^2}\mathbf{e_d} \tag{2}$$

$$E = mc^2 \tag{3}$$

Eq. (1) is the **Newtonian equation of motion**, and Eq. (2) shows the **gravitational force**. These two are the foundations of the Newtonian mechanics. Eq. (3) is derived from the Lorentz transformation (special relativity). There arises a question whether the masses in them are the same or not. Another question is whether all of the equations are correct as they are or any one needs an amendment. For checking this question, at least the mass should be defined properly.

Eq. (1) is correct at least when the initial velocity v_0 is zero, however, is questionable for $v_0 \gg 0$. According to the special relativity, the following relativistic mass m_{rel} is proposed from the Lorentz transformation.

$$m_{rel} = \frac{1}{\sqrt{1 - v^2/c^2}}m \tag{4}$$

Eq. (1) of Newtonian equation of motion is valid in the form of

$$\mathbf{F} = \frac{d(m_{rel}\mathbf{v})}{dt}\,. \tag{5}$$

1.2. Energy in the standard physics

Eq. (3) indicates the equivalence of mass and energy. A decrease in mass converts to the energy of radiations. However, in the standard physics, the "particle" is strictly differentiated from the "energy" although they can convert to the other. They insist that only the particle has a mass, and the mass of any energy is zero. In order to claim it, the mass should be clearly defined first.

The mass of a static particle is usually called as the rest mass. If an energy is added to a particle, and accelerates it to the velocity v, the added energy is equal to the kinetic energy. In the Newtonian mechanics, the kinetic energy is given as below.

$$\Delta E = E_k = m \int_0^v v\, dv = \frac{1}{2} m v^2 \tag{6}$$

According to the special relativity, it is shown as follows.

$$E_k = \frac{mc^2}{\sqrt{1 - v^2/c^2}} - mc^2 = \frac{1}{2} m v^2 \left(1 + \frac{3v^2}{4c^2} + \frac{5v^4}{8c^4} + \cdots \right) \tag{7}$$

The total energy becomes as below.

$$E = E_r + E_k = mc^2 + E_k = m_{rel} c^2 \tag{8}$$

In the standard physics, energy other than a particle does not have a mass, but has a momentum. Light has the following momentum.

$$p_\gamma = \frac{E_\gamma}{c} \tag{9}$$

Using the relativistic mass, the momentum and the energy of light are expressed as below.

$$p_\gamma = m_{rel} c\,, \qquad E_\gamma = m_{rel} c^2 \tag{10}$$

The light has its relativistic mass greater than zero. However, they do not regard it as a mass due to the following reason. The special relativity insists the relativistic energy-mass relation shown by

$$E^2 - (pc)^2 = (mc^2)^2 \,. \tag{11}$$

Here they argue that mc^2 is invariant by a frame to measure and E varies. It means that the rest energy is invariant and the total energy varies by a frame. It has been widely accepted, but is it really correct? They regard the rest mass m as invariant by frame change and call it as the **invariant mass** or simply as **mass**.

However, we argue that the **total energy should be invariant** and its distribution to the rest energy and the kinetic energy differs depending on a frame to measure. We will explain this point from the next chapter. Now onward, we will use m_r for the rest mass and m for the mass of total energy. “What the mass is” will be thoroughly discussed later.

Consider a static particle shown by E in Eq. (12). In a moving frame, it has a kinetic energy as shown by E'.

$$E = E_r = m_r c^2 \,, \qquad E' = E'_r + E_k \tag{12}$$

The special relativity insists that $E_r = E'_r = m_r c^2$ and $E \neq E'$. However, the total energy should be invariant $E = E'$, we argue. How shall we define the rest energy E'_r in a moving frame? We will define various types of energy in the Chapter 8.

✧ **Note**

From the next chapter, we will explain the necessary knowledges of the ECT for deriving a new dynamics. If you are familiar with the ECT enough, please **skip** to the **Chapter 8**.

Chapter 2: Mistake of the light speed invariance

2.1. Light speed invariance

One of critical mistakes of the standard physics is the light speed invariance. As a general property of waves, the propagation velocity does not change as the source moves relative to the medium. However, if the observer moves, the propagation velocity in the observer's frame varies by its speed to the medium. Therefore, if the earth moves toward the medium, the light speed should vary depending on the direction to measure. This is called as the **anisotropy** of the light speed.

✧ Michelson-Morley experiment

Michelson and Morley reported experiments on the anisotropy in 1881 and 1887. The light from the source was divided by a half-mirror into a beam reflected to the vertical direction and a transmitted straight beam. Both beams were reflected at the same distance, returned to the half-mirror, and were led to the observation device. If the apparatus is moving relative to the medium, there will be a difference in the propagation velocity between the vertical and horizontal beams. The combined beam passes through two slits apart with a very small distance, propagates radially from each slit, and forms interference fringes on the screen. They thought that when the whole apparatus was rotated, the speed of motion of the light path relative to the medium would change, and the spacing and position of the interference fringes would change. However, they did not detect a notable change in the spacing or position of fringes. After that, many people conducted the similar experiments, but no change was seen. It was then concluded that the light speed is constant regardless of the observer's motion, and further concluded that the **light has no medium**. This is the famous law of the **light speed invariance** in the standard physics.

2.2. Mis-leading from the light speed invariance

This interpretation then evoked the **Lorentz transformation**, which is the essence of the **special relativity**, and the idea that the **space expansion is accelerating**. However, the detection principle of the anisotropy was not fully described even in the Michelson's papers, but they only mentioned to expect a change in fringe positions. Later physicists did not verify the detection principle, either. Since before reported the ECT, we have been claiming time to time that the Michelson-Morley-like experiments cannot detect the change in position but can detect that in brightness of the interference wave.

✧ **Detection principle of the anisotropy of light speed**

There are two very important points to note. One is that the two beams join and go to the detection device, but not one beam through one slit and the other through another one. The combined mixed wave passes through both slits, that is, each beam passes through both slits. The second point is that they are trying to observe the difference in the frequency of the two beams. In modern experiments, instead of observing interference fringes using slits, two beams are combined and the difference in frequency is measured as the difference frequency (beat note frequency).

If there is a difference in the light speed between the two split beams that are emitted simultaneously, there will be a time difference Δt in the arrival at the junction. Because their mixed wave is measured, the two beams must arrive at the same time. Therefore, the light that takes Δt longer is emitted Δt earlier. There is hence a phase difference of $\omega\Delta t$ between the two beams at the detector. The displacement of the mixed wave of the two beams is expressed as below.

$$A_1 + A_2 = A\sin(kx - \omega t) + A\sin\big(kx - \omega(t + \Delta t)\big)\ , \qquad k = \omega/v \qquad (13)$$

Even if the light speeds in the two arms are different, since both beams are in the same direction from the half-mirror to the detector after they join, the light speed v is the same, and the angular frequency ω and wavenumber k are also the same for both beams. Here we devise to express the phase of A_1 as $0 = -\omega\Delta t/2 + \omega\Delta t/2$ and that of A_2 as $-\omega\Delta t = -\omega\Delta t/2 - \omega\Delta t/2$.

$$A_1 + A_2 = A\sin\left(kx - \omega t - \frac{\omega\Delta t}{2} + \frac{\omega\Delta t}{2}\right) + A\sin\left(kx - \omega t - \frac{\omega\Delta t}{2} - \frac{\omega\Delta t}{2}\right) \quad (14)$$

The mixed wave above can be transformed as follows.

$$A_1 + A_2 = 2A\cos\frac{\omega\Delta t}{2}\sin\left(kx - \omega t - \frac{\omega\Delta t}{2}\right) \quad (15)$$

This is the **interference wave in the detector** after the two beams join. This is a very important formula. When Δt changes due to a rotation of the apparatus by such as the rotation of the earth, it indicates the following results: (1) Even if Δt changes due to a rotation of the apparatus, the directions of the both beams are the same, so the light speed v, frequency ω, wavenumber k and wavelength are the same between the both beams. (2) The amplitude and phase of the mixed wave (interference wave) change with the change of Δt due to a rotation of the apparatus. As a conclusion, Michelson-Morley-like experiments **cannot** detect the **change in spacing or position** of interference fringes, but **can** detect the change in the **brightness**.

In fact, some phenomena suggesting the anisotropy of the light speed have been already mentioned. In the Michelson-Morley experiment, the interference fringes were unstable, and often dimmed or disappeared. They adjusted the mirrors to restore the image. They presumed that it was caused by noise by external factors such as vibration and temperature change. However, the main cause seems to be the change in the brightness due to the change in the phase difference between the two beams. A more direct example is the following. It was presented at a workshop (DICE) in Italy in 2008 or 2010 that circadian variations in the information transfer speed were observed. In the transmission of information between a satellite, Chile and the East Coast of the US, the difference in the transmission speed between the points was observed to fluctuate with a period of one day. The graph of the circadian variation was really beautiful, and I immediately felt that this was exactly the data showing the anisotropy of the light speed. I asked the speaker "isn’t it the light speed itself?", but he answered "it is not the light speed but a speed of information transmission”. This transmission of information is performed by radio waves, and the transmission speed is equal to the propagation speed of electromagnetic waves (light).

✧ **Conclusion on the light speed invariance**

It is clearly wrong that the light speed invariance has been experimentally proved. At least it has not been measured. Let us leave it as unknown, then seek for the real feature of the light propagation logically.

3.1. Discovery of the ECT

✧ 4D spherical model of universe before the ECT

Before the energy circulation theory was released, I had reported the following model of the universe.

The space of universe is filled with energy called the "**space energy**". It acts as the medium and its vibrations are our observable energies like a particle and light. The cosmic energy is distributed in the 3D surface of a 4D sphere (sphere in 4D space) with expansion.

From the natures of waves in general, I proposed the formula of the light speed as a function of the cosmic radius. From the light speed equation, I derived the Hubble diagram, in which the distances and the redshifts of stars are plotted, and the observed data of supernovae showed an excellent fit to the expected curve from the model. It means that dark energy, which is expected in the standard cosmology, does not exist.

Since a particle is a vibration of the medium, its motion should show features as a wave. I proposed and published in 2013 the **acceleration factor** f_a, which modifies Eq. (1) of the Newtonian equation of motion.

$$\boldsymbol{\alpha} = \frac{\mathbf{F}}{m} f_a \,, \qquad f_a = \left(1 + \frac{v^2}{c^2}\right)^n \quad (n \geq 1) \tag{16}$$

It seems similar to the relativistic factor in Eqs. (4) and (5). However, $n < 1$ was denied since it resulted in zero of the kinetic energy of light. I expected $n = 1$ at that time, but there was no rationale for it.

✧ Idea of a new force

The above model of universe resulted in excellent fits to the observed universe. However, there was lacking of absolute rationales to derive the model. It was based on the general properties of waves, but seemed insufficient to convince physicists.

The particle should be a stationary wave of the space energy, I expected. For a vibration, there should work a tension in the medium. It was likely that the so-called elementary particle would be a circulation of energy, but what kind of a force would control the circulation? The electromagnetic force was a potential candidate, but it should not be applied to non-charged particles. While struggling a lot, I could not find the force, then I gave up on thinking about it.

One day, it suddenly occurred to me, "maybe there is a force that acts on the movement of energy". After a while, I became convinced that it was an incredible breakthrough that would solve everything. Between two energies, there acts a **force based on the movement of energy**, that is, the momentum, while the gravitational force works based on the magnitude of energy.

Then I reached the **energy circulation theory**.

3.2. Fundamentals of the energy circulation theory

The energy circulation theory is to develop the essences of the universe logically from scratch. At first, the "**energy**" is defined as anything that exists in the universe. Other physical properties are defined secondarily from energy distribution, motion, and interactions. In the existing physics on the contrary, energy is defined secondarily from mass, acceleration, charge, electric potential, etc.

✧ Starting points of the energy circulation theory: two premises

The energy circulation theory starts from the following two promises.

（1） Energy can be expressed by an intrinsic energy and its velocity, shown by the below formula.

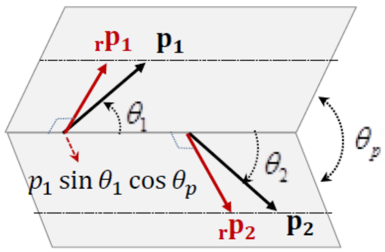
$$E = M_1 {V_1}^2 = M_2 {V_2}^2 = mc^2 \tag{17}$$

（2） Between energies, the force shown by the below formula works based on their momentums.

$$F = K_f \frac{{}_{\mathrm{r}}\mathbf{p}_1 \cdot {}_{\mathrm{r}}\mathbf{p}_2}{d^2} = K_f \frac{p_1 p_2}{d^2} \cos\theta_p \sin\theta_1 \sin\theta_2 \tag{18}$$

K_f ： Fundamental force constant

Fig. 1. Momentum components to the distance



(In addition, gravitational force acts on the amount of energy.)

These two premises are assumptions and correspond to **axioms** in mathematics. We named the development from these two premises as the "**energy circulation theory ECT**".

✧ Intrinsic energy

There are many ways to select the **intrinsic energy** in (1) depending on the direction to take, etc., but in all combinations, the product of the magnitude of the intrinsic energy and the square of its velocity gives the same energy. The motion in a direction orthogonal to the direction of interest is incorporated in the intrinsic energy. An intrinsic energy has the property of mass, but we define such intrinsic energies that move at the light speed as the "**mass**" in the narrow sense.

✧ Fundamental force

We named the force of (2) as the "**fundamental force**". The **charge** exerting the force is a vector, and the formula includes three angular factors in addition to the distance. We define the "**momentum**" as the product of the intrinsic energy and its velocity by $\mathbf{p} = M\mathbf{V}$. The momentum alters depending on how the intrinsic energy is taken, but if an intrinsic energy of a common velocity is taken, its magnitude is proportional to the amount of the intrinsic energy. As shown in Fig. 1, $\square_{\mathbf{r}}\mathbf{p}$ is the orthogonal component of a momentum to the distance direction in the plane of the momentum and the distance direction, and its amount is given by $\square_{r}p = p\sin\theta$. The magnitude of the fundamental force is the inner product of these components of the two momentums, and the direction is the distance direction. A plus force is repulsive, and a minus force is attractive. Anti-parallel energy movements circulate by attraction of the fundamental force, and form an **energy circulation**. The momentum and the fundamental force constant K_f change depending on how the intrinsic energy is taken, but the force is the same. Unless otherwise mentioned, K_f shall be the fundamental force constant for the intrinsic energies that move at the light speed c (the light speed shall be discussed later).

✧ Novel physics from the energy circulation theory

The energy circulation theory ECT requires an essential restructuring of the existing physics. In 2018, the first article on the ECT was published in Reports in Advances of Physical Sciences. After that, important consequences from the ECT were successively reported, and by now a total of seven papers listed below have been published in the same journal.

[1] Energy circulation theory

It is the first article claiming the ECT with the title of "Energy circulation theory to provide a cosmic evolution, electric charge, light and

electromagnetism”. Based on the ECT, it reported the cosmic evolution, the origin of the electric charge, the mechanism of light emission and the light speed, summary of the electromagnetism, etc. The light is a wave in hidden-space dimensions.
https://doi.org/10.1142/S242494241850007X

[2] Structures and interactions of quantum particles

For each of major known particles (leptons, mesons, baryons), the composition of energy circulations, energy (mass), spin and decay reactions were shown.
https://doi.org/10.1142/S2424942419500014

[3] Galactic evolution (without dark matter)

Here were reported the cosmic evolution including how galaxies were formed. It is regulated by the fundamental force working on momentums. There neither exists the black hole at the center nor dark matter in the halo, which were assumed in order to explain the galactic rotation and its velocity in the existing physics.
https://doi.org/10.1142/S2424942420500048

[4] Quantum mechanics

Here was explained that the existing quantum mechanics includes some contradictions and essential mistakes. A novel wave equation for particles by the ECT was reported. The wave function for a particle shows its energy distribution in the real space.
https://doi.org/10.1142/S2424942421500018

[5] Gamma-ray bursts

The gamma-ray burst is the phenomenon that gamma-rays are released when a galactic seed separates to two ones, where gravitational waves (waves in space-space dimensions) are also released. The details of the

galactic seed separation, and the changes in force and potential energy between the two galactic seeds were shown with mathematical formulas.
https://doi.org/10.1142/S2424942421500055

[6] Formation of various shapes of galaxies

There are many types of galaxies, including ellipse, ring, disc, spiral, and barred spiral ones. Here the formation of each type of them was shown by simulation. In the existing physics, formations of any types remain as mystery.
https://doi.org/10.1142/S2424942422500049

[7] Novel electromagnetism

Based on the ECT, the electric charge, electric current, and magnetic charge were redefined, and the electromagnetism was reconstructed. The magnetic charge density, which corresponds to the magnetic field, around an electric current was quantitively derived.
https://doi.org/10.1142/S2424942423500081

4.1. Energy circulation and intra-circulation force

✧ Energy circulation

The "**energy circulation**" here shall be what the intrinsic energy is distributed even and continuously on the circumference. We take the amount M of the intrinsic energy as the sum of local ones ΔM on the whole circumference ($d\Delta M/d\theta = 0$).

$$M = \int_0^{2\pi} \Delta M d\theta = \Delta M \int_0^{2\pi} d\theta = 2\pi\Delta M \tag{19}$$

We express the **energy distribution** by a wave function ψ. In the case of a circular motion, it becomes as follows, where μ is the radius, and ω is the frequency.

$$\psi = [X \quad Y] = [\mu\cos\omega t \quad \mu\sin\omega t] = \mu(\cos\omega t + i\sin\omega t) \tag{20}$$

Each local intrinsic energy has a phase θ as $\omega t + \theta$, but the intrinsic energy is expressed as a whole by taking the sum of $0 \le \theta \le 2\pi$. We use the **notation**, by which $\boldsymbol{E\psi}$ means that the energy E is distributed at ψ. The wave function ψ shows a common distribution (position of existence) not only for the total energy but for all such as the intrinsic energy and the momentum. They are expressed by a common wave function ψ as follows.

$$E\psi, \qquad M\psi, \qquad p\psi \tag{21}$$

The amount of the total energy can be expressed by the intrinsic energy and its circular velocity as follows.

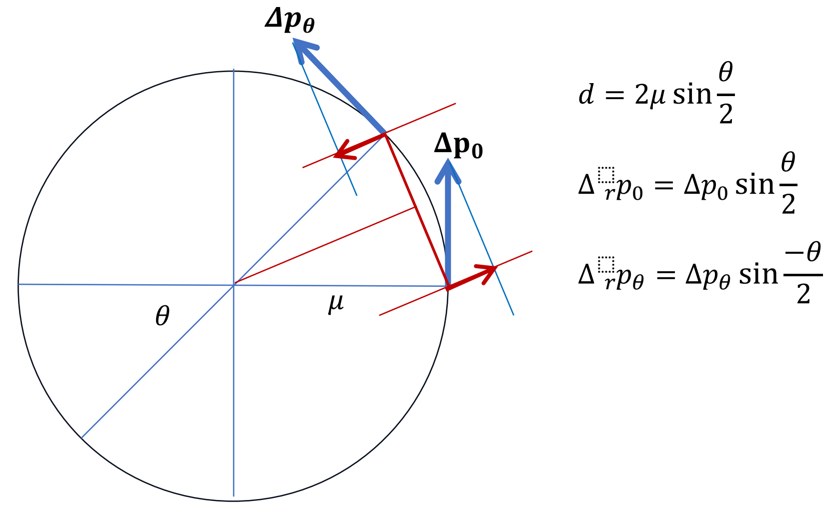
$$E = MV_c{}^2 = M\mu^2\omega^2 \tag{22}$$

✧ Intra-circulation force

Next, let us consider the **intra-circulation force** that acts within an energy circulation.

Let μ be the radius, and consider two local momentums $\mathbf{\Delta p_0}$ and $\mathbf{\Delta p_\theta}$ with the central angle θ apart on the circumference.

Fig. 2. Two local momentums on the circumference



As shown in Fig. 2, the distance of the two local momentums (energies) is

$$d = 2\mu \sin\frac{\theta}{2}\ . \tag{23}$$

The force acting between $\mathbf{\Delta p_0}$ and $\mathbf{\Delta p_\theta}$ is given by the below formula.

$$\Delta F = K_f \frac{\Delta p_0 \Delta p_\theta}{d^2} \sin\frac{\theta}{2} \sin\frac{-\theta}{2} = -K_f \frac{\Delta p_0 \Delta p_\theta}{4\mu^2} \tag{24}$$

Remarkably, the angle θ and the distance d disappear from the formula, and the amount of the force is decided only by the radius of the circulation. The local momentum Δp_0 receives the following centripetal force from the momentum p of the whole circulation. The force in a tangential direction is set off each other to be zero.

$$cF_\perp = -K_f \frac{\Delta p_0}{4\mu^2} \int_0^{2\pi} \Delta p_\theta \sin\frac{\theta}{2} d\theta = -K_f \frac{\Delta p_0}{4\mu^2} \frac{p}{2\pi} 4 = -K_f \frac{p \Delta p_0}{2\pi\mu^2} \tag{25}$$

$$cF_{//} = -K_f \frac{\Delta p_0}{4\mu^2} \int_0^{2\pi} \Delta p_\theta \cos\frac{\theta}{2} d\theta = 0 \tag{26}$$

✧ Radius of energy circulation

If the intra-circulation force is balanced with the centrifugal force, it is a stable energy circulation. Consider an energy circulation, in which the intrinsic energy of M is circulating with the radius of r at the circulating velocity of V_c by the 2D expression. Since the formula of the centrifugal force by the mass is known, let us take the intrinsic energy m that moves at the light speed c by the 3D expression. m is moving helically with the main circular component V_c and the local circular component v_c.

$$E = MV_c^2 = m(V_c^2 + v_c^2) = mc^2 \tag{27}$$

On a local intrinsic energy Δm, the centrifugal force and the intra-circulation force balance and show the following relation from Eq. 18.

$$\frac{\Delta m V_c^2}{r} - K_f \frac{mV_c \Delta m V_c}{2\pi r^2} = 0 \tag{28}$$

$$2\pi r = K_f m$$

$$r = \frac{K_f}{2\pi} m = \frac{K_f}{2\pi c^2} E \tag{29}$$

As shown in Eq. (29), the **radius of an energy circulation is proportional to its energy**, and is independent of the circulating velocity.

4.2. Inter-circulation force between energy circulations

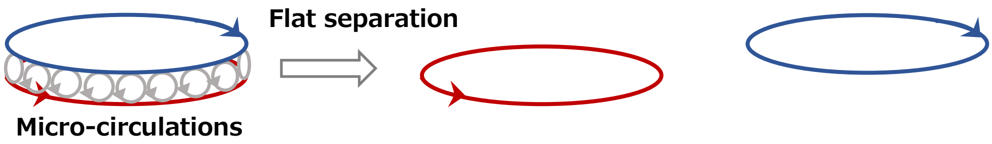
Let us examine a force working between two energy circulations. There are two types of working directions. The **flat interaction** is within the plane, and the **orthogonal interaction** is in the vertical direction to the plane. There are two cases of the relative circulating directions; same or opposite (conjugate).

Here, we skip the derivations of formulas for inter-circulation forces, and show only the results. If you are interested in mathematical details, please refer to the below on the same website as that of this book.

✧ Flat interaction of opposite directions (conjugate pair)

Two energy circulations of the opposite frequencies form the coupled conjugate pair, which we also call as a double circulation. While this conjugate pair is internally attracted by a strong force, the vertical distance of the two circulations does not become zero, but as shown in Fig. 3, many **micro-circulations** are formed in the circumference direction and the vertical direction to it in a short distance. A coupled conjugate pair has a three-dimensional structure if the vertical direction is taken in account. When expressed in three dimensions, a coupled conjugate pair can be regarded as a series of many micro-circulations on the main circumference.

Fig. 3. Structure of a coupled conjugate pair and flat separation



We call such a separation within the plane as shown in Fig. 3 as the "**flat separation**". Let us see the force working between them during the flat separation.

Consider a single circulation S of frequency ω and $\overline{S}$ of $-\omega$. We take the approximation to use the two antiparallel linear momentums orthogonal to the distance direction, which are apart by the distance of diameter. While skipped the derivation, the following force works in the flat interaction between S and $\overline{S}$. x is the relative distance to the diameter $x = d/2\mu_0$, and x_0 is the diameter of micro-circulations.

$$\boldsymbol{F_{flat}}(\boldsymbol{S}-\boldsymbol{\overline{S}}) = Q_p f_{flat}(x)\,. \tag{30}$$

$$\boldsymbol{Q_p} \equiv K_f \frac{{p_h}^2}{\pi^2 {\mu_0}^2} \tag{31}$$

$$\boldsymbol{f_{flat}(x)} \equiv \frac{x-1}{((x-1)^2+{x_0}^2)^{3/2}} + \frac{x+1}{((x+1)^2+{x_0}^2)^{3/2}} - \frac{2x}{(x^2+{x_0}^2)^{3/2}} \tag{32}$$

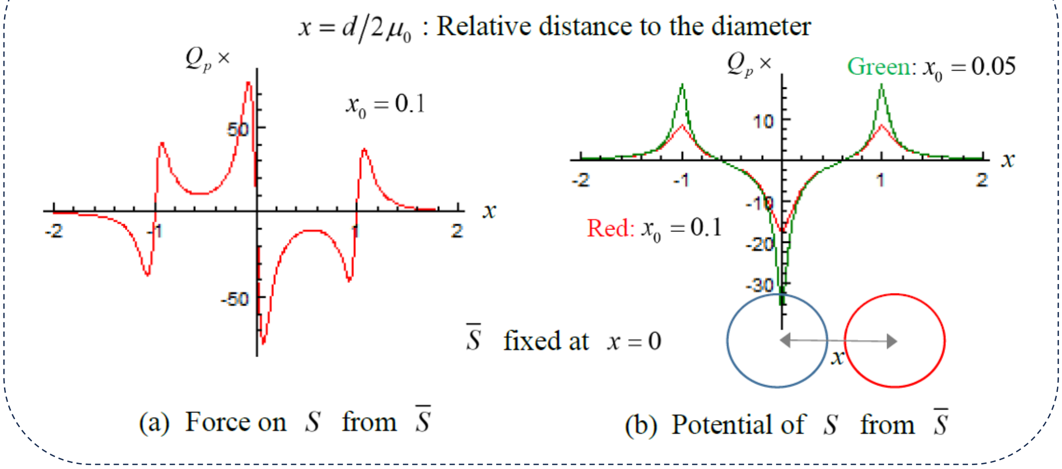
The minus force is attractive in $x > 0$ and repulsive in $x < 0$. The potential energy is obtained by $U(x) = -\int F(x)dx + C$ as follows. We set $U(\infty) = 0$.

$$\boldsymbol{U_{flat}(S - \overline{S})} = -\int Q_p\, f_{flat}(x)dx$$

$$= Q_p \left(\frac{1}{\sqrt{(x-1)^2+{x_0}^2}} + \frac{1}{\sqrt{(x+1)^2+{x_0}^2}} - \frac{2}{\sqrt{x^2+{x_0}^2}} \right) \tag{33}$$

The force and potential energy are shown in Fig. 4. In $|x| < 1$, the force is attractive, working them to return to a coupled pair at $x = 0$. The potential energy shows a trough at $x = 0$. At $|x| = 1$, the force is zero, and the potential energy shows a crest. In $|x| > 1$, the force is repulsive and accelerates them to recede.

Fig. 4. Flat interaction of conjugated single circulations



The above equations and graphs are under the primary consideration for elementary circulations with the radius μ_0, but are **applicable** also to **larger circulations**.

✧ Flat interaction of same direction

As the space expands, an energy circulation divides to two ones, then which separate. Let us see the flat interaction of two single circulations of the same circular direction. In this case, micro-circulations are not formed at a small distance, but the interaction of local circulations becomes notable. Let x_0 be the diameter of local circulations.

Compared with the force between S and $\overline{S}$, signs of the components of the force between S and S are just reverse. Therefore, the force and the potential energy are the negative of those of S and $\overline{S}$.

$$\boldsymbol{F}_{flat}(\boldsymbol{S}-\boldsymbol{S}) = -F_{flat}(S-\overline{S}) = -Q_p f_{flat}(x) \qquad (34)$$

$$\boldsymbol{U}_{flat}(\boldsymbol{S}-\boldsymbol{S}) = -U_{flat}(S-\overline{S}) \qquad (35)$$

✧ Orthogonal interaction of opposite directions (conjugate pair)

As an example of opposite directions, let us see the orthogonal interaction of S and $\overline{S}$. The distance has the minimum value x_0, which is the diameter of micro-circulations. We take the range $x \geq x_0$. Take a minute local momentum $\Delta\mathbf{p}_\alpha$ on the circumference of S. Divide the circulating momentum of $\overline{S}$ to two halves; $\mathbf{p}_0$ and $\mathbf{p}_\pi$. Their directions are arc, but let us use the approximation treating them as linear, parallel or antiparallel to $\Delta\mathbf{p}_\alpha$, with the distance $2\mu_0$ (diameter of S). Calculate the orthogonal distance component of the force. Integrate it from $\alpha = 0$ to $\alpha = 2\pi$, then we get the following force. Q_p is given by Eq. (31).

$$\boldsymbol{F}_{ort}(\boldsymbol{S}-\overline{\boldsymbol{S}}) = Q_p f_{ort}(x) \quad (x \geq x_0) \qquad (36)$$

$$\boldsymbol{f}_{ort}(\boldsymbol{x}) \equiv \frac{x}{(x^2+1)^{3/2}} - \frac{1}{x^2} \qquad (37)$$

The potential energy is given as below.

$$\boldsymbol{U}_{ort}(\boldsymbol{S}-\overline{\boldsymbol{S}}) = Q_p \pi \left(\frac{1}{\sqrt{x^2+1}} - \frac{1}{x}\right) \quad (x \geq x_0) \qquad (38)$$

✧ Orthogonal interaction of same direction

Take the case of two circulations $(S-S)$ of the same circular direction. x_0 is the diameter of local circulations. Here, we consider only the interaction of main circulations for the range $x \geq x_0$.

Signs of the force and potential energy are reverse to those of different directions $(S-\overline{S})$ as below. Q_p is given by Eq. (31).

$$\boldsymbol{F_{ort}(S-S)} = -F_{ort}\left(S-\overline{S}\right) = -Q_p f_{ort}(x) \quad (x \geq x_0) \tag{39}$$

$$\boldsymbol{U_{ort}(S-S)} = -U_{ort}\left(S-\overline{S}\right) = Q_p \pi \left(\frac{1}{x} - \frac{1}{\sqrt{x^2+1}}\right) \quad (x \geq x_0) \tag{40}$$

Chapter 5: Summary of cosmic evolution

5.1. Cosmic separation

✧ Energy

We provide that the "**energy**" is a vibration in **multiple** (M) **dimensions** while we do not know the number M of dimensions. The same energy can be expressed in any number of dimensions depending on how the intrinsic energy is taken. If it is expressed in one dimension, the energy from motions in the rest M-1 dimensions shall act as the intrinsic energy, which is vibrating in one dimension. In order to vibrate in one dimension, a force is required. For providing this force, one additional dimension is necessary and the motion should become a circulation in two dimensions. In this case, energy is circulating by the centripetal force due to the fundamental force, and in any direction within the two-dimensional circular plane, it is vibrating one-dimensionally.

✧ Cosmic separation

Let us express the "**pre-cosmos**" before the expansion by M/2 pairs of 2D energy circulations. We provide that the pre-cosmos was symmetric in all dimensions. In order to be symmetric, each 2D circulation should bind to a circulation of opposite direction to form a **coupled conjugate pair**. While this conjugate pair is internally attracted by a strong force, the vertical distance of the two circulations does not become zero, but as shown in Fig. 3, many **micro-circulations** are formed in the circumference direction and the vertical direction to it in a short distance. A coupled conjugate pair has a three-dimensional structure if the vertical direction is taken in account.

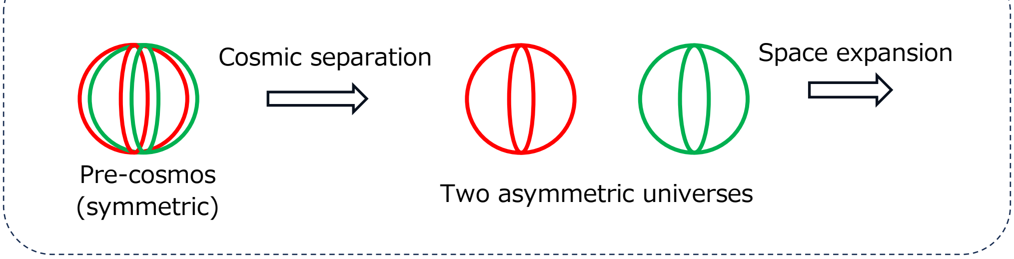
When the width of the energy distribution of the pre-cosmos becomes larger than a threshold in any one-dimensional direction, the original amplitude in it cannot be maintained and it expands. Among the M/2 pairs, the coupled conjugate pair including this direction separates horizontally (flat separation) as shown in Fig. 3. Jointly with this separation, another coupled conjugate pair, the vertical direction of which is the prolonged one, separate orthogonally. We call it as the "**orthogonal separation**". In this way, the pre-cosmos divides into two universes. We call it as the "**cosmic separation**". We can express the cosmic separation as below, where μ is the radius and φ is a function to show a circulation.

$$E\mu_{pre}(\varphi_{12}:\varphi_{12}^* + \varphi_{34}:\varphi_{34}^*) \longrightarrow \frac{E}{2}\mu_u(\varphi_{12} + \varphi_{34}) + \frac{E}{2}\mu_u(\varphi_{12}^* + \varphi_{34}^*) \qquad (41)$$

$$\varphi = \exp(i\omega t) = \cos\omega t + i\sin\omega t \ , \ \varphi^* = \exp(-i\omega t)$$

Fig. 5 shows its 3D image. In reality, the circulations are in the X_1-X_2 plane and in the X_3-X_4 plane, in total 4 dimensions. If the prolonged direction is X_1, the pair in X_1-X_2 separates horizontally, and the pair in X_3-X_4 separates orthogonally.

Fig. 5. 3D image of the cosmic separation in 4D space



5.2. Space expansion

✧ Space expansion

In each separated universe, many local micro-circulations on the circumference of the pre-cosmos have been lost, the balance with the centrifugal force as one circulation breaks, then the space expansion in the 4 dimensions of the two circulations starts. We call it as the "**space**

expansion". The remaining dimensions other than these four are called as the "**rest dimension**". A coupled conjugate pair in rest dimensions (e.g. X_5-X_6 plane) has the vertical direction of a rest dimension (e.g. X_7), and remains as the state of a coupled conjugate pair while the location in the expanded 4 dimensions separated to two universes. Even if the space expands, the radius keeps constant, and the circular momentums are set off each other to be zero. Since any directions in the rest dimensions are orthogonal to any directions in the 4D space, the circular energies there act as an intrinsic energy for motions in the expanding 4D space.

✧ Energy distribution of the universe

The two energy circulations (frequency ω) separated by the cosmic separation can be expressed in the 4D polar coordinates as below. Simultaneously with the cosmic separation, the space expansion starts, and the radius expands and the frequency decreases. However, for convenience, let us consider the state immediately after the separation.

$$\mathbf{X} = [\mu \quad \theta_1 \quad \theta_2 \quad \theta_3] = [\mu \quad \omega t \quad \theta_2 \quad \omega t] \tag{42}$$

Expressing it in the 4D cartesian coordinates, we get the below.

$$\mathbf{X} = \mu \begin{pmatrix} \cos\omega t + i\sin\omega t\cos\theta_2 + j\sin\omega t\sin\theta_2\cos\omega t \\ +k\sin\omega t\sin\theta_2\sin\omega t \end{pmatrix} \tag{43}$$

The imaginary units i, j, k are unit vectors of directions orthogonal each other and to the real part. Here, for the circulation of $\mu\theta_1$, we take the base vectors; $\mathbf{e_0}$ for the radius and $\mathbf{e_1}$ for the arc on the circumference.

$$\mathbf{e_0} \equiv \cos\theta_1 + i\sin\theta_1 \tag{44}$$

$$\mathbf{e_1} \equiv \cos(\theta_1 + \pi/2) + i\sin(\theta_1 + \pi/2) = i\mathbf{e_0} \tag{45}$$

The radius and the arc can be expressed as $\mu\mathbf{e_0}$ and $\mu\theta_1\mathbf{e_1} = \mu\omega t\mathbf{e_1}$. Jointly with j and k, $\mathbf{e_1}$ forms the **3D cartesian coordinates**, in which Eq. (43) is expressed by the following formula.

$$\mathbf{X} = \mu\big(\omega t\mathbf{e_1}\cos\theta_2 + \sin\theta_2\,(j\cos\omega t + k\sin\omega t)\big) \tag{46}$$

✧ **Space energy, apparent energy, and spacia**

The cosmic energy, which shows the two energy circulations expanded in 4D, is distributed on the 3D surface of the 4D sphere (ball). We call the 3D surface as the "**space dimensions**" and the radius of the 4D sphere as the "**hidden dimension**". The width of the energy distribution in the hidden dimension H is very thin and invariant with the space expansion. Let $2\mu_0$ be this width, and treat the 4D sphere of the radius μ_0 as the **minimum unit space**. While the cosmic energy as a whole is circulating and asymmetric, we divide it into two parts; the symmetric one "**space energy**" and the asymmetric one "**apparent energy**". The space energy is distributed evenly in the whole space of the universe, and is a collection of coupled conjugate circulations. The circular momentums of the pair are set off each other to be zero, and the fundamental force does not act there. The space energy in the unit space of the radius μ_0 is named as the "**spacia**". The distribution and the amount of the spacia can be expressed as below.

$$E_\mu \psi_\mu = E_\mu \mu_0 \big(\exp(i\omega_0 t) + \exp(-i\omega_0 t)\big) \tag{47}$$

$$\exp(i\omega_0 t) = \cos\omega_0 t + i\sin\omega_0 t$$

$$E_\mu = m_\mu {v_c}^2 = m_\mu {\mu_0}^2 {\omega_0}^2 = m_\mu c^2 \tag{48}$$

5.3. Development of the apparent energy

An apparent energy is given as an additional circulation to one component of the coupled circulations of the spacia. This apparent energy can also be expressed as a vibration of the space energy as a medium.

The distribution of the apparent energy in the 3D space immediately after the cosmic separation can also be expressed by Eq. (46). θ_2 is a parameter to show a location, and shows continuous values in the range of $0 \le \theta_2 \le \pi$.

✧ Cyclic decomposition

The apparent energy immediately after the separation can no longer be maintained as a circulation, and make the separations and decompositions of energy circulations. Each circulation expands and decomposes all at once on the whole circumference to give a huge number of daughter circulations perpendicular to the parent one. We call it as the "**cyclic decomposition**". Although the ring distribution of the daughter circulations is not a continuum, intra-ring attractive forces due to the fundamental force act, and the **ring rotates by taking over the parent circulation**. Since this **ring of daughter circulations** is not a continuous energy circulation, its radius increases continuously by increasing distances between each other as the space expands.

✧ Asymmetric large-scale motions in the universe

As the space expands, the cyclic decompositions are repeated in many rounds, giving an infinite number of daughter circulations with much lower energies. As the energy value of an energy circulation decreases, the cyclic decomposition stops with it. We call those at this state as the "**galactic seed**". In this way, large-scale movements in the universe are shown, such as a galaxy cluster, in which galaxies gather in a ring and rotate, a supercluster, in which galaxy clusters gather in a ring and rotate, and the further rotation of gathered superclusters.

✧ Galactic seed division and separation

After a cyclic decomposition became no longer possible, a galactic seed started to divide to two seeds, which separated each other. We call the process as the "**galactic seed separation**". In a galactic seed separation, the decrease in potential energy converts to the increase in receding velocity and the energy emission. This emission of energy is the **gamma-ray-burst**, in which gamma-rays, after-glow radiations, and gravitational waves are released.

✧ Stellar seed release from a galactic seed

Once the energy of a galactic seed decreases to a certain level, a further galactic division-separation becomes impossible. Then, releases of stellar seeds from the galactic seed begin. The "**stellar seed**" is the daughter energy circulation from the galactic seed. Depending on the types of source galactic seeds; isolated one, rotating binary seeds, or two attached ones, and the kinds of stellar seed release; linearly one by one, or simultaneously in a ring, various shapes of galaxies are formed.

5.4. Elementary single energy circulations

✧ Elementary single circulation

As the space expands, a stellar seed further releases daughter circulations, and finally causes a cyclic decomposition to form a proto-stellar system with a star in the center.

The smallest one of the energy circulations released in this way is the "**elementary single circulation**" that has the same radius μ_0 as that of the spacia. As an energy circulation quantized in the 4D space, any one of a smaller radius than it is impossible. We express an elementary single circulation in **hidden-space dimensions** as iS, and that in **space-space dimensions** as S. The elementary single circulation has the same circulating velocity as that of the spacia shown by Eq. (48), and let m_0 be its intrinsic energy. Its energy distribution and amount are shown as follows.

$$E_{(iS)}\psi_{iS} = E_{(iS)}[X \quad H] = E_{(iS)}\mu_0(\cos\omega_0 t + i\sin\omega_0 t) \tag{49}$$

$$E_{(S)}\psi_S = E_{(S)}[X \quad Y] = E_{(S)}\mu_0(\cos\omega_0 t + j\sin\omega_0 t) \tag{50}$$

$$E_{(iS)} = E_{(S)} = m_0 {v_c}^2 = m_0 {\mu_0}^2 {\omega_0}^2 \tag{51}$$

We call the coupled conjugate pair consisting of two conjugate circulations as the "**double circulation**" shown by iD or D.

Chapter 6: Particle and radiation

6.1. Particle

✧ Definition of particle

In the standard physics, the term "particle" is not defined although they distinguish the particle from the energy and allow them to convert to the other. They insist that a particle is composed of a few of 17 kinds of elementary particles, but which are not defined. They insist that each elementary particle has its unique property or conserved quantity. Treating them as a fundamental one that cannot be divided further, they abandon to seek for their structure or composition.

As we have explained up to here, an energy circulation has the following properties.

(1) It can be expressed as a circulating intrinsic energy, which is a continuum spread on the whole circumference.

(2) Due to the intra-circulation force, it keeps a constant radius depending on its energy quantity.

(3) It can be static to the space energy.

(4) It interacts with another one by the inter-circulation force, which is attractive or repulsive.

From these properties, we can define the particle as follows.

*The "**particle**" is defined as an **energy circulation**.*

For details on the energy circulation, please come back to the Section 3.1.

✧ Quantum particle

We define the "**quantum particle**" as a single or a complex of energy circulations within one spacia. The spacia is a sphere in 4D space, and has six planes orthogonal each other. In the three space-space planes, three space-space elementary circulations in maximum can occupy. In the three hidden-space planes, three in maximum hidden-space elementary circulations can occupy.

Elementary circulations: $S,\ iS,\ D,\ iD,\ D^{\#},\ iD^{\#},\ D^{\#\#}$

D stands for a coupled conjugate pair called as a double circulation. i stands for a hidden-space circulation. # stands for excited one of $\omega = 2\omega_0$.

The composition of elementary circulations for major particles were reported in the paper [2].

6.2. Linear wave (radiation)

✧ **Hidden-space wave and space-space wave**

The elementary single circulations iS and S were explained in the Section 4.4. The radius μ_0 and the circulating velocity $v_c = \mu_0\omega_0$ are the same in the elementary single circulation and the spacia. In order to be **quantized**, the circular frequency ω should be integral multiple of ω_0. If ω is smaller than ω_0, it cannot be static to the space energy, and propagates linearly. Let us call it as **radiation** or simply as **wave**, distinguished from the particle. A hidden-space dimensional wave is the "**light**" (used as a term for any frequencies). In a space-space dimensional radiation, a fluctuation in space-space dimensions is propagating in a space direction, that is, an intrinsic energy is helically moving in the 3D space. The space-space wave of the smallest radius is the **neutrino**, which is generated by the division of S as a pair with **antineutrino**.

$$S \longrightarrow \nu(H) + \overline{\nu}(\overline{H}) \tag{52}$$

We call them as a "**hemi-circulation**" in space-space dimensions, and express it by the symbol H. A space-space wave of larger radius and energy is so called the **gravitational wave**, many of which were released in a galactic seed separation.

✧ **Light speed**

The propagation speed of light is equal to the **circulating velocity of the spacia**.

$$\textbf{Light speed}: \ c = v_c = \mu_0 \omega_0 \tag{53}$$

As the space expands, the number of spacias increases, but at this time, the radius μ_0 of the spacia remains unchanged, and the frequency ω_0 decreases. The light speed c also decreases as ω_0 decreases. When the cosmic radius becomes x from x_0, the number of spacias increases to the cube of x/x_0. The intrinsic energy m_μ of the spacia is invariant, and the total energy does not change, either. When ω_0 is expressed as a function of the cosmic radius x, we have the following relation.

$$m_\mu {\mu_0}^2 \left(\omega_0(x_0)\right)^2 = \frac{x^3}{{x_0}^3} m_\mu {\mu_0}^2 \left(\omega_0(x)\right)^2 \tag{54}$$

Let us express the light speed as a function $c(x)$ of the radius.

$$c(x) = \sqrt{\frac{{x_0}^3}{x^3}} * c(x_0) \tag{55}$$

Since ${x_0}^3/x^3$ is equal to the ratio of the space energy density, this Eq. (55) indicates that the light speed is proportional to the square root of the medium density. As the space expands, the **energy** of the **elementary single circulation** shown by Eq. (51) also decreases as ω_0 decreases (the intrinsic energy m_0 remains constant). However, its following **relation to the light speed** remains **unchanged**.

$$E_{(iS)} = E_{(S)} = m_0 c^2 \tag{56}$$

Chapter 7: Electric and magnetic phenomena

7.1. Definition of electric charge and electric force

✧ Definitions of the electric charge and the magnetic charge

As shown in Eq. (18), the charge of the fundamental force is a momentum, which is a vector having a direction. The direction in the hidden dimension H is orthogonal to any directions in the three space dimensions. Therefore, the angular factors in Eq. (18) disappear for the force in a space direction between two momentums in H. Since H is one dimension, a momentum there and the distance direction are on one plane. If we take $\cos\theta_p = 1$, θ_1 and θ_2 are $+\pi/2$ or $-\pi/2$, and $\sin\theta_1$, $\sin\theta_2 = +1$ or -1. Therefore, the charge for this force is a scalar, and take a plus or minus value. In the ECT, the momentum in the hidden dimension H of a hidden-space dimensional circulation is defined as the "**electric charge**". The electric charge takes a plus or minus value depending on the direction of momentum in H. In addition, the momentum in the space dimensions of a hidden-space circulation is defined as the "**magnetic charge**". In the 3D space, the electric charge is a **scalar charge** but the magnetic charge is a **vector charge**.

✧ Electric force

The intra-circulation force of iS in the space direction between the two halves of the circle is given as below.

$$F_x = -\frac{8}{\pi^2} K_f \frac{{p_h}^2}{(2\mu_0)^2} \tag{57}$$

For derivation, please refer to

"Novel electromagnetism by the energy circulation theory".

http://www3.plala.or.jp/MiTiempo/NovelEM-E.pdf

Here, we define the half circle momentum p_h as the "**elementary electric charge**" e and the constant K_e as follows.

$$K_e \equiv \frac{8}{\pi^2} K_f \,, \qquad e \equiv p_h = \frac{m_0 \mu_0 \omega_0}{2} = \frac{m_0 c}{2} \tag{58}$$

Express the intra-circulation force of Eq. (57) by the electric charge.

$$F_x = -\frac{8}{\pi^2} K_f \frac{{p_h}^2}{(2\mu_0)^2} = -K_e \frac{e^2}{(2\mu_0)^2} \tag{59}$$

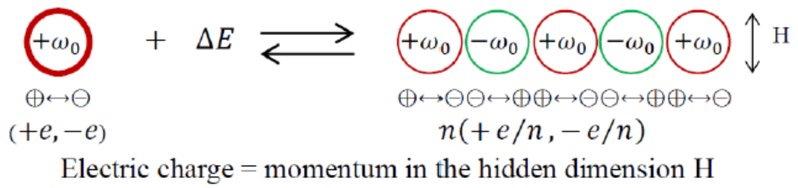
This is the "**electric force**" that acts in the **space direction** between the electric charges in an iS.

7.2. Elementary charge pair eCP

✧ Elementary charge pair

When an iS absorbs a light (light quantum) and energy is added, it prolongs in the space dimension to plural (n) circulations over n spacias as shown in Fig. 6. The number n of circulations is limited to an odd number. This prolonged one is called as the "**elementary charge pair** (**eCP**)".

Fig. 6. Prolongation of hidden-space single circulation iS



✧ Connected electric force

By the addition of energy, the potential energy in the space direction is increased, but the sum of the momentums in the hidden dimension, that is, that of electric charges does not change. The space directional force in each circulation is given as follows from Eq. (59).

$$F_x = K_e \frac{(e/n)(-e/n)}{(2\mu_0)^2} = -K_e \frac{e^2}{(2n\mu_0)^2} = -K_e \frac{e^2}{d^2} \tag{60}$$

At each adjacent part of two circulations, the outward and inward intra-circulation forces set off each other to be zero. The force of Eq. (60) remains only at the two ends of an elementary charge pair. This is equal to the virtual force if it is assumed that elementary charges $+e$ and $-e$ would be separated by the distance $d = n \times 2\mu_0$ (length of eCP). This is the true feature of the electric force acting between an electron and a proton. The electric charges $+e$ and $-e$ are dispersed between the proton and electron, and each of the elementary charge is the sum of the charges. In an atom, the electron-proton pair includes an eCP. A neutrino is attached to the minus end of the eCP, which is an electron. A space-space single circulation is attached to the plus end of the eCP, which is a proton (proton includes also other circulations). We named this force within an eCP as the "**connected electric force**". Thus, the force between a proton and an electron is a connected electric force, not an electrostatic force between isolated electric charges.

✧ Prolongation of eCP

The length of an eCP changes by absorption or emission of light (light quantum).

$$eCP(x) + \gamma \rightleftarrows eCP(x + \Delta x)\,, \qquad x = 2n\mu_0 \tag{61}$$

The energy addition is made by absorbing one cycle of light (light quantum), but the added energy will remain within the eCP. Therefore, the increase in energy (per one second) is $\Delta E = h\nu^2$. Conversely, when an eCP becomes shorter, the difference energy is released as light. In this case, the light emission is that of a light quantum of one cycle, and is not a continuous light.

The added energy ΔE has a maximum. If an eCP absorbs a light of higher energy than the maximum (**higher frequency**), it will **divide to two**.

$$\Delta E = U(x+\Delta x) - U(x) = K_e e^2 \left(\frac{1}{x} - \frac{1}{x+\Delta x}\right), \qquad \Delta E_{max} = \frac{K_e e^2}{x} \tag{62}$$

$$eCP(x) + \Delta E \longrightarrow eCP(x_1) + eCP(x_2) \tag{63}$$

✧ **Magnetic charge by rotation of eCP**

The magnetic charge of a static eCP is zero since those of opposite directions are set off. An eCP can rotate around the hidden dimension axis, and its velocity components in each space direction can flexibly change. By rotating around the H axis, a free eCP with nothing added to either end is rotating in the space dimensions around its center. It shows the “**rotating magnetic charge**”, which is the core feature of the magnetism.

Chapter 8: Acceleration of a particle

8.1. Types of energy of a particle

✧ Types of energy in the standard physics

In the standard physics, the energy of a particle is regarded as the sum of rest energy E_r, kinetic energy E_k, and potential energy E_p.

$$E = E_r + E_k + E_p = m_r c^2 + E_k + E_p \tag{64}$$

They treat the rest energy very special, claiming that both the rest mass m_r and the light speed c in it are invariant by change of a frame to measure. On the other hand, the total energy E varies by a frame, they insist. However, as explained in the Chapter 1, there is no rationale for their claim, and the total energy should be invariant, we argue.

✧ Types of energy in the ECT

For a particle moving linearly, it is possible to express its energy by the rest energy and the kinetic energy. Take a case that the elementary space-space single circulation S is accelerated to a speed of v with or without an addition of energy. If energy is not added, $m = m_0$.

$$E = m_0 c^2 + \Delta E = mc^2 = E_r + E_k \,, \qquad E_r \equiv E - E_k \tag{65}$$

Let us define the "**rest energy**" E_r as the total energy E minus the kinetic energy T_k. The kinetic energy will be defined later.

In order for the fundamental force constant K_f to be constant, let us use such intrinsic energies that move at the common velocity c, and call them as the "**mass**", expressed by small letter m. By addition of an energy, the mass increases from m_0 to m.

In this case, the intrinsic energy m is helically moving, and the energy of the particle can be expressed as follows. μ_0 is the radius of the spacia.

$$E = mc^2 = m\left({C_r}^2 + v^2\right) = m{\mu_0}^2\omega^2 + mv^2 \tag{66}$$

$$E_c \equiv m{C_r}^2 = m{\mu_0}^2\omega^2\,, \qquad E_L \equiv mv^2 \tag{67}$$

C_r is the circulating velocity. Let us call the circular component $E_c = m{C_r}^2$ of the energy as the "**circular energy**" and the linear component $E_L = mv^2$ as the "**linear energy**". The circular energy shows a **nature as particle**.

Thus, there are two ways in expressing the energy of a moving particle; by the rest and kinetic energies, or by the circular and linear energies.

✧ Free motion of a particle

When a free particle (take S for this case) is accelerated by a **force**, it undergoes a change in the **potential energy** of the force. The **total energy does not change** by the value of the speed, and is shown as below.

$$E = m_0c^2 = m_0c^2 + E_k + \Delta E_p = E_r + E_k \tag{68}$$

It is a very important note that a **change** in the **potential energy** is **incorporated** in the **rest energy**. We will define the kinetic energy and the potential energy later in the Chapter 9.

Let v be the speed. By the expression of helical motion, the linear energy is $E_L = m_0v^2$. There is the following relation.

$$E = m_0c^2 = m_0(c^2 - v^2) + m_0v^2 = m_0{C_r}^2 + m_0v^2 \tag{69}$$

As v increases, C_r and E_c decrease.

$$E_c = m_0{C_r}^2 = m_0(c^2 - v^2) \tag{70}$$

8.2. Types of frame and types of motion

✧ Types of frame of reference

There is the **absolute frame** that is stationary to the space energy. However, for our observation from the earth, it is almost impossible to use the absolute frame.

The "**moving frame**" is primarily defined as that moving to the space energy. The frame attached to the surface of the earth is a typical example. We use the term "**stationary frame**" also for a frame stationary to a given moving frame not only to the space energy. We use the term "**moving frame**" also for a frame moving to such a secondary stationary frame. Please be cautious about **to what** the frame is stationary or moving.

✧ **Types of motion**

There are two kinds of motion. One is **static** under a force and the other is **in a free motion**. Let us take a moving frame. Being **static** in a moving frame means that it is co-moving with the frame in the space energy. In many cases, the moving frame is attached to a reference body, such as the earth. In the case that there works a force between an object and the reference body, if the object receives the force of F, the reference body receives the force of $-F$. When a particle is static in the frame, it receives a force but its energy does not change as long as it remains at the same position. However, if we try to increase the distance from the reference body with keeping the particle static, energy should be added. This is an increase in potential energy, which will be explained later in the Chapter 9.

The "**free motion**" is defined as any motions **without a change** in the total **energy** of the object. It has a broader concept than the free fall. We have already explained the free motion in the previous section by Eqs. (68), (69) and (70).

8.3. Acceleration

✧ **Acceleration of a static particle**

If the initial velocity is zero, the Newtonian equation of motion of Eq. (1) should hold. In the case of S, it is shown as below.

$$F = m_0 \alpha = m_0 \frac{dv}{dt}\,, \qquad (\text{for } v = 0) \tag{71}$$

This equation is valid only for the range of $0 \le v \le 0 + dv$.

✧ Acceleration of a moving particle

For the same case of Eq. (69) in a free motion, consider a point, where the moving velocity is $v = v_1$. Let us take the frame moving at v_1 in the moving direction of the particle. The energy composition is as follows in the moving frame, the total energy of which is equal to that in the stationary frame.

$$E = M\left({C_r}^2 + V^2\right) = m_0 c^2 \tag{72}$$

C_r is the circulating velocity, V is the linear velocity, and M is the intrinsic energy. Either in the stationary frame or the moving frame, the circulating velocity C_r is the same in Eq. (69) and Eq. (72), and given by

$${C_r}^2 = c^2 - v^2\,. \tag{73}$$

V and v have the below relation.

$$V = v - v_1 \tag{74}$$

At the point of $v = v_1$, that is, $V = 0$, it shows only the circular energy.

$$E = M{C_r}^2 = m_0 c^2 \tag{75}$$

Since the initial velocity is zero as $V = 0$, the acceleration should obey the Newtonian equation of motion in the moving frame at the point of $v = v_1$.

$$F = M\frac{dV}{dt}\,, \qquad (\text{at } V = 0) \tag{76}$$

The moving speed of the frame is constant as v_1. Therefore, the acceleration in the moving frame is equal to that in the stationary frame.

$$\frac{dV}{dt} = \frac{d(v - v_1)}{dt} = \frac{dv}{dt} = \alpha \tag{77}$$

From the relations of Eqs. (73), (75) and (77), Eq. (76) is converted to as follows, where v is limited to v_1.

$$F = M\frac{dV}{dt} = m_0\frac{c^2}{C_r{}^2}\frac{dv}{dt} = \frac{m_0 c^2}{c^2 - v_1{}^2}\alpha = \frac{m_0}{1 - v_1{}^2/c^2}\alpha \tag{78}$$

For any values of v_1, this equation holds if $0 \le v_1 < c$. Thus, we get the equation of motion for S as follows.

$$F = \frac{m_0}{1 - v^2/c^2}\alpha \tag{79}$$

✧ Acceleration of iS

Let us see the acceleration of iS, which is the elementary single circulation in hidden-space dimensions. As explained in the Section 5.4, the static iS has the same intrinsic energy m_0 and circulating velocity $v_c = c$ as those of S. If the circulation is in H and X, the velocity in the space dimension X is $v_x = c$, and that in H is $v_h = c$. The velocity in the hidden dimension H is limited to $c = \mu_0\omega_0$, but the velocity in the space dimensions can be divided into components in three space directions.

$$\mathbf{v_r} = \mathbf{v_x} + \mathbf{v_y} + \mathbf{v_z} \tag{80}$$

$$c^2 = v_x{}^2 + v_y{}^2 + v_z{}^2 \tag{81}$$

When an iS is linearly moving at v in X, the intrinsic energy m_0 is helically moving with a circular motion in Y-Z. Its energy is given as follows.

$$E = m_0 c^2 = m_0\left(v_y{}^2 + v_z{}^2\right) + m_0 v_x{}^2 = m_0 C_r{}^2 + m_0 v^2 \tag{82}$$

This is identical to Eq. (69) of the space-space single circulation S. Therefore, the equation of motion of **Eq. (79)** is **valid** also for iS.

8.4. Novel equation of motion

✧ Universal equation of motion

While we will explain in more detail in the Section 9.1, if a particle is accelerated by a force, it is accompanied by a decrease in potential energy for the force. It is in a free motion as shown below, same as Eq. (68).

$$E = m_0 c^2 + \int_0^v F\,dv + \int_0^x (-F)dx \tag{83}$$

Since it is in a free motion, Eq. (79) is valid, and we get the following equation in general by replacing m_0 by m, where $m \equiv E/c^2$ and $0 \le v < c$.

Equation of motion: $$\mathbf{F} = \frac{m}{1 - v^2/c^2}\boldsymbol{\alpha} = \frac{m}{1 - v^2/c^2}\frac{d\mathbf{v}}{dt} \tag{84}$$

m is the mass, which is given by $m \equiv E/c^2$ from the total energy. Eq. (84) is the **novel equation of motion** for any particles, replacing the Newtonian one. It is valid not only for elementary single circulations, but also for elementary double circulations (D, iD) and their exited forms $(D^{\#}, iD^{\#})$. Since any particle is a complex of elementary circulations, Eq. (84) holds also for any quantum particles and their aggregates. Eq. (84) is valid also for non-particle energy, which will be explained in the next section.

✧ Interpretation of the novel equation of motion

There are two kinds of interpretation of the equation of motion shown by Eq. (84) depending on the frame.

(1) In the stationary frame:

The mass is $m = E/c^2$, and the acceleration factor f_a differs by the velocity of the particle.

$$\alpha = \frac{F}{m} f_a\,, \qquad f_a = 1 - \frac{v^2}{c^2} \tag{85}$$

(2) In the co-moving frame:

The initial speed V_0 of the particle is set as zero, and the frame is moving at v to the space energy. The intrinsic energy M varies by the velocity of the frame.

$$F = M\alpha\,, \qquad M = \frac{m}{1 - v^2/c^2} \tag{86}$$

Measurements on the earth are usually based on a **frame moving** jointly with the surface of the earth, and we call it as a **stationary frame** to a specific point on the surface. Strictly speaking, such a stationary frame is a co-moving frame with earth surface in the space energy. However, in many cases, since the moving speed of the frame is very small compared with the light speed, the effect of its velocity can be ignored and we can regard the frame as a stationary frame. The interpretation of (2) is in the co-moving frame with a particle to such a stationary frame.

8.5. Acceleration of light and neutrino

✧ Acceleration of light

Eq. (84) of the equation of motion is applicable even to non-particle energy. In the case of light, the moving speed is $v = c$, and the circulating velocity is $C_r = 0$. The acceleration factor $f_a = 1 - v^2/c^2$ in the direction of propagation is zero. Therefore, the light speed cannot be accelerated.

However, in a direction vertical to the propagation, the velocity is $v = 0$. C_r in Eq. (84) can be the velocity in orthogonal directions not limited to a circulating velocity. In the case of light, the whole energy $E = mc^2$ acts as the orthogonal component $mC_r{}^2$ and the linear velocity is $v = 0$ for a vertical direction. The acceleration factor is one, $f_a = 1$, in the direction. This causes the phenomenon of gravity lensing. Since the acceleration is always orthogonal to propagation, the propagation direction is altered by a force, but the amount of the light speed does not change.

✧ Motion of neutrino

The space-space single circulation S divides to a neutrino and an antineutrino. The energy of neutrino is $E_{(\nu)} = m_0c^2/2$, which is too small to be quantized as a particle (energy circulation). The neutrino cannot be static in the space energy. A neutrino should linearly move but has a non-zero circular energy.

When S divides to two halves, the direction of circulation is the same for them, and a repulsive force by orthogonal interaction works between them. As for the force, please refer to Eq. (39). The two halves are in a free motion and accelerated according to the equation of motion by Eq. (84). Soon after the division, their velocities reach the maximum v, which is close to and practically equal to c.

$$m_0 c^2 = \frac{m_0}{2} c^2 + \frac{m_0}{2} c^2 = \frac{m_0}{2}\left({C_r}^2 + v^2\right) + \frac{m_0}{2}\left({C_r}^2 + (-v)^2\right)$$
$$= \frac{m_0}{2}\left({\mu_0}^2 \omega^2 + v^2\right) + \frac{m_0}{2}\left({\mu_0}^2 \omega^2 + (-v)^2\right), \qquad v \approx c \qquad (87)$$

The circular frequency is ω in both of them, but we usually use the helicity to the moving direction as a spin. If we express $(-v)$ in Eq. (87) as v, the circular frequency to it becomes $(-\omega)$. We call one half as a neutrino, and the other half as an antineutrino. From here, let us call both of them as a neutrino, collectively.

If a neutrino attaches to the minus end of an eCP, it forms an electron. A free neutrino moves linearly at almost the light speed. The distribution to circular and linear energies can be flexible. The circular frequency ω can change flexibly. Even if ω becomes several times, there is almost no influence on the linear velocity, which remains as almost c.

Similar to the case of light, a neutrino receives an acceleration in a vertical direction by a force. As explained so far, the neutrino is not a particle but is a propagation of a wave in space-space dimensions, though it retains a particle-like nature by a small circular energy.

Chapter 9: Kinetic energy and potential energy

9.1. Kinetic energy

Take the case that a static particle of a mass m will be accelerated to a speed v by receiving a force F.

We mentioned the addition of energy to a particle by Eq. (65). How is such an energy added? It is achieved by an absorption of energy. In the case that a particle is accelerated by receiving a force, it should be accompanied by a decrease in the potential energy corresponding to the force. The **acceleration** of a particle **by any force** falls into a **free motion** as expressed by Eq. (68) or Eq. (69).

Let x be the moved distance from 0 when the velocity increases from 0 to v. The energy is given as follows.

$$E = mc^2 = mc^2 + E_k + \int_0^x \left(-F(x)\right)dx \tag{88}$$

This equation is equivalent to stating that the work $\int_0^x Fdx$ accelerates the particle from $v = 0$ to $v = v$. The third term of Eq. (88) is the difference in **potential energy** ΔE_p. We will define the potential energy in the next section. The second term is the **kinetic energy**, given as below.

$$E_k = \int_0^x F(x)dx \tag{89}$$

The force is given by Eq. (84) as a function of velocity. Let us calculate the kinetic energy.

$$E_k = \int_0^x \frac{m}{1 - v^2/c^2} \alpha dx = m\int_0^x \left(1 - \frac{v^2}{c^2}\right)^{-1} \frac{dv}{dt} dx = m\int_0^v \left(1 - \frac{v^2}{c^2}\right)^{-1} vdv \tag{90}$$

$$T \equiv 1 - \frac{v^2}{c^2}, \qquad \frac{dT}{dv} = -\frac{2v}{c^2} \tag{91}$$

$$m\int T^{-1} v \frac{c^2}{-2v} dT = -\frac{mc^2}{2}\int T^{-1}\, dT = -\frac{mc^2}{2}\log T + C \tag{92}$$

Take the definite integral from $v = 0$ to $v = v$, then we get the following formula for the kinetic energy.

$$\textbf{Kinetic energy}: \; E_k = -\frac{mc^2}{2}\log\left(1-\frac{v^2}{c^2}\right) \tag{93}$$

This is the **novel equation of kinetic energy**. By Taylor's expansion, it is rewritten as below.

$$E_k = \frac{1}{2}mv^2\left(1+\frac{1}{2}\frac{v^2}{c^2}+\frac{1}{3}\frac{v^4}{c^4}+\frac{1}{4}\frac{v^6}{c^6}+\cdots\right) = \frac{1}{2}mv^2\sum_{n=1}^{\infty}\frac{1}{n}\left(\frac{v^2}{c^2}\right)^{n-1} \tag{94}$$

As v approaches c, the kinetic energy diverges to infinite.

I would like to emphasize Eq. (88) again. If acceleration is made by a force, the total energy E is not the sum of the energy mc^2 before the acceleration and the kinetic energy E_k, but it remains as mc^2 since E_k is set off by the decrease in potential energy. Please confirm again the difference between the **circular energy** and the **rest energy**. The rest energy is given as $E_r = mc^2 - E_k$ whereas the circular energy is $E_c = m(c^2 - v^2)$. The **kinetic energy**, which is shown by Eq. (93) or Eq. (94), is also different from the **linear energy** shown by mv^2.

9.2. Potential energy in a free motion

✧ Definition of the potential energy

In the Chapter 8, we used the change ΔE_p in potential energy for discussing energy. The property of the potential energy of a particle exists based on a force that works on it. In order to receive a force, a counterpart, which gives the force, is necessary. Let x be the distance between them. We can define the "**potential energy**" in general as follows, where $E_p(\infty)$ is set as zero since no interaction works at $x = \infty$.

$$\textbf{Potential energy}: \ E_p(x) \equiv \int_{\infty}^{x} \big(-F(x)\big)dx \tag{95}$$

$$\textbf{Domain of } \boldsymbol{x}: \ \text{region where the force acts}$$

For a force, which has a limited domain of x, a standard point $x = x_0$ to show $E_p(x_0) = 0$ is set instead of $x = \infty$.

✧ Potential energy in a free motion

Here is a very important point that a **potential energy can exist only in the region where the force acts**. Consider the case that a static ball is hit by another ball and is accelerated to a velocity v. Similar to Eq. (69), the motion of the intrinsic energy (mass) m gets from a circular to a helical one as shown below.

$$mc^2 = m{C_r}^2 + mv^2 = m(c^2 - v^2) + mv^2 \tag{96}$$

Before and after the collision, there is no potential energy defined for the balls. Only during the short period, in which they attach each other, the forces F and $-F$ act, and the potential energy exists. Take x as the location of the target ball. Let $0 \le x \le \Delta x$ be the region of x during the collision, in which the velocity increases from 0 to v. Only in this region, the potential energy exists as shown below, which is set as $E_p(0) = 0$.

$$E_p(x) = \int_{0}^{x} \big(-F(x)\big)dx \ , \qquad 0 \le x \le \Delta x \tag{97}$$

The kinetic energy is given as follows, where the total energy of the particle is invariant.

$$E_k(x) = -E_p(x) \ , \qquad E(x) = mc^2 + E_k(x) + E_p(x) = mc^2 \tag{98}$$

This is duly a free motion in the region of $0 \le x \le \Delta x$. Since the rest energy is defined as the total energy minus the kinetic energy, it becomes the rest energy plus the potential energy from Eq. (98).

$$E_r(x) = mc^2 - E_k(x) = mc^2 + E_p(x) \tag{99}$$

The **potential energy** is **incorporated** in the **rest energy**. The relation of Eq. (99) is valid for $0 \leq x \leq \Delta x$. In $x > \Delta x$, the potential energy does not exist, and both $E_r(x)$ and $E_k(x)$ get **constant** as $E_r(\Delta x)$ and $E_k(\Delta x)$.

This is a typical case of acceleration by a mechanical force. In the standard physics, the total energy is said to be increased by the kinetic energy. However, that is wrong. The total energy does not change.

By the expression of a helical motion with the circular and linear energies, the energy is expressed as follows.

$$E = m{C_r}^2 + mv^2 = m(c^2 - v^2) + mv^2 \tag{100}$$

v is a function of x, but the relation holds for the whole range of x regardless whether a force works or not.

In the case of a quantized particle, the velocity v does not change without receiving a force. By receiving a force F during the position change Δx from the outside counter, it gets an energy, which converts to the increase in kinetic energy. However, in the same time, it **affects the force $-F$ to the counter** during the same Δx, which results in the **decrease in the potential energy** of the particle. In total, the energy of the particle does not change. The counter results in a decrease in kinetic energy and an increase in potential energy, keeping the total energy unchanged.

9.3. Potential energy of a static particle under a force

✧ Change of potential energy of a static particle under a force

In a free motion, the total energy is kept as constant regardless of its velocity. However, if a **static particle**, which is receiving a continuous force $F(x)$, moves by a distance of Δx and **remains static**, the total energy has been increased by the difference in potential energy. The linear energy is kept as always be zero. Let m_1c^2 be the initial energy $E(x_1)$ at $x = x_1$.

$$E(x_1 + \Delta x) = E(x_1) + \int_{x_1}^{x_1+\Delta x} \big(-F(x)\big)\, dx = m_1 c^2 + \Delta E_p \tag{101}$$

$$E(x_1) = m_1 c^2 = mc^2 + E_p(x_1)$$

The relation $E_r(x) = mc^2 + E_p(x)$ of Eq. (99) is valid also in this case since a force acts. By the helical expression, it is the circular energy shown below.

$$E(x_1 + \Delta x) = m_1 c^2 + \Delta E_p = E_c = (m_1 + \Delta m)c^2 \tag{102}$$

The change in potential energy is incorporated in the rest energy or the circular energy, where the mass is changed. The circulating velocity is equal to the light speed $v_c = \mu_0 \omega_0 = c$.

✧ Potential energy of D (double circulation)

The elementary double circulation D in space-space dimensions is the coupled conjugate pair of S and $\overline{S}$.

$$S + \overline{S} \longrightarrow D\big(S{:}\overline{S}\big) + \Delta E \tag{103}$$

$$E_{(S)} + E_{(\overline{S})} = E_{(D)} + \Delta E \tag{104}$$

ΔE is equal to the difference ΔE_p in potential energy of the separated S and $\overline{S}$ from $x = x_0$ to $x = \infty$. From the definition of potential energy, $\Delta E = -E_p(x_0)$. $E_p(x_0)$ is the potential energy at $x = x_0$. The energy of D is given as follows.

$$E_{(D)} = 2m_0 c^2 - \Delta E = 2m_0 c^2 + E_p(x_0) \tag{105}$$

The potential energy from the orthogonal interaction is given by Eq. (38). Let us call this potential energy at $x = x_0$ as the **potential energy of D**.

$$U_{ort}\big(S - \overline{S}\big)(x = x_0) = Q_p \pi \left(\frac{1}{\sqrt{{x_0}^2 + 1}} - \frac{1}{x_0} \right) \equiv U_{(D)} < 0 \tag{106}$$

$U_{(D)}$ is equal to $E_p(x_0)$. The energy of D is expressed as follows.

$$E_{(D)} = 2m_0 c^2 + U_{(D)} \tag{107}$$

We do not know yet either the value of Q_p or that of x_0. The value of $U_{(D)}$ is determined but not yet known. In the paper [2], we set as follows in order to calculate the energy of each quantum particle based on its composition of elementary circulations.

$$U_{(D)} = -0.6m_0c^2\,, \qquad E_{(D)} = 1.4m_0c^2 \tag{108}$$

There we expected as $m_0c^2 \approx 100\ \mathrm{MeV}$, and we set as follows.

$$E_{(S)} = E_{(iS)} := 100\ \mathrm{MeV}\,, \qquad E_{(D)} := 140\ \mathrm{MeV}\,, \qquad E_{(iD)} := 135\ \mathrm{MeV} \tag{109}$$

Under these settings of energy of elementary circulations, we induced the energies of most of known quantum particles (baryons, mesons, leptons), which showed very good fits to the measured values.

✧ Gravitational potential energy of a static particle on the earth

The energy of a static particle on the earth varies with its height due to a change in its gravitational potential energy. Let r be the distance from the center of earth, M be the mass of the earth, and $m(r)$ be the mass of a particle. The energy of the particle is

$$E(r) = m(r)c^2\,. \tag{110}$$

The gravitational potential energy is given as below.

$$U(r) = \int_{\infty}^{r} \big(-F(r)\big)\,dr = \int_{\infty}^{r} G\frac{Mm(r)}{r^2}\,dr \tag{111}$$

Let r_0 be a standard value of r such as the sea level. The energy $E(r)$ can be expressed as follows. mc^2 is the energy at $r = \infty$.

$$E(r) = mc^2 + U(r_0) + U(r) - U(r_0) = m(r_0)c^2 + \Delta U(r - r_0) \tag{112}$$

The energy at r is the sum of the energy at r_0 and the difference in the potential energy between r and r_0. Here, let us approximate $m(r)$ as the constant $m(r_0)$. The difference $\Delta U(r - r_0)$ in the potential energy is approximated as below, which is smaller a little than the real value if $r > r_0$.

$$\Delta U(r - r_0) = \int_{r_0}^{r} G\frac{Mm(r)}{r^2}\,dr \approx GMm(r_0)\left(\frac{1}{r_o} - \frac{1}{r}\right) \tag{113}$$

$E(r)$ is approximated as follows.

$$E(r) \approx m(r_0)c^2 + GMm(r_0)\left(\frac{1}{r_o} - \frac{1}{r}\right) \tag{114}$$

Usually, we measure the rest energy (mass) of a particle at around the sea level. Let the sea level be the standard distance r_0, and h be the height from it as $r = r_0 + h$. If h is relatively smaller enough than r_0, we can further approximate it as follows. $g = GM/r_0$ is the gravitational acceleration.

$$E(r) \approx m(r_0)c^2 + GMm(r_0)\left(\frac{1}{r_o} - \frac{1}{r_0 + h}\right) \approx m(r_0)c^2 + m(r_0)gh \tag{115}$$

In the ECT, we express the mass of an elementary single circulation by the symbol m_0 as $E_{(S)} = E_{(iS)} = m_0c^2$. This value of energy does not include the gravitational potential energy from the earth. The actual measurement is not on m_0c^2, but is on $m(r_0)c^2$ on the earth. Not only elementary single circulations, but any elementary circulations, quantum particles, and aggregated particles obey the relation shown by Eq. (115) or Eq. (112). The rest mass (energy) of any material increases at high altitudes due to an increase in the gravitational potential energy from the earth.

✧ Effect of potential energy on an atomic clock

The energy of an atom and the energy levels of its atomic orbitals are also greater at higher altitudes than those on the ground level. A radiation frequency of an atom at a higher altitude also increases. The energy level of a clock transmission of an atom also increases. Therefore, an **atomic clock** needs the **adjustment** of its **clock frequency for one second** by the altitude of its location.

Pound and Rebka reported in 1960 a difference of the gravitational potential energy over a height of 22.5 meters as a shift in frequency of the electromagnetic radiation of ^{57}Fe. They detected a frequency difference of $\Delta\nu/\nu = 2.5 \times 10^{-15}$, which was equal to the theoretical energy difference of

$\Delta E/E = gh/c^2$. Another example is the adjustment of an atomic clock on a satellite.

In the standard physics, they insist that the change of clock frequency comes from the difference of the gravitational redshift by the height from the general relativity. They claim that time passes faster at a higher altitude than at a lower altitude. However, as explained in this book, their claims are wrong since they are subjected that the rest mas is kept invariant.

✧ Kept static under a force first, then in a free motion

Our usual measurements on the earth are a mixture of a fixed state as stationary and a free motion. Let us see the energies under such a mixed motion. Consider a particle of $E = mc^2$ static in the space energy. Act a force $F(x)$ on it in the direction of x, where $F(\infty) = 0$. As an initial state, make it static to the space energy at $x = x_1$ under receiving the force $F(x)$. Remove the stopper and make it be in a free motion.

The total energy = rest energy at $x = x_1$, where $v = 0$, is the sum of mc^2 and the potential energy at x_1 as shown below.

$$E(x_1) = mc^2 + E_p(x_1) = E_r(x_1) \equiv m_1 c^2 \qquad (116)$$

$$m_1 = m + \frac{E_p(x_1)}{c^2}\,, \qquad E_p(x_1) = \int_{\infty}^{x_1} \big(-F(x)\big)\,dx \qquad (117)$$

Let us refer the mass of $E(x_1)$ to as m_1. If the force is attractive $F(x) < 0$, m_1 is smaller, and if repulsive, greater than m.

In the subsequent free motion, the rest energy is given by

$$E_r(x) = mc^2 + E_p(x)\,. \qquad (118)$$

The kinetic energy is given from the difference in potential energy as shown below.

$$E_k(x) = -\Delta E_p(x - x_1) = E_p(x_1) - E_p(x) \qquad (119)$$

The total energy is the sum of the rest energy and the kinetic energy.

$$E(x) = E_r(x) + E_k(x) = mc^2 + E_p(x_1) = E(x_1) \qquad (120)$$

Thus, we can confirm that $E(x) = E(x_1) = m_1c^2$. By the expression of helical motion, the energy is expressed by circular and linear energies.

$$E(x) = E_c(x) + E_L(x) = m_1(c^2 - v^2) + m_1v^2 , \qquad (v\text{: function of } x) \qquad (121)$$

Chapter 10: Motion in a moving frame

Consider a particle of a mass m, which is linearly moving at a velocity v. Its energy is shown as below in the stationary frame to the space energy.

$$E = mc^2 = m{C_r}^2 + mv^2 = m(c^2 - v^2) + mv^2 \tag{122}$$

Take a frame moving at v_1 to the space energy in the direction of v. In this moving frame, the circulating velocity is the same as that in the stationary frame because the direction of v_1 is orthogonal to the circulation. The linear velocity is $V = v - v_1$. The energy of the particle can be expressed as below.

$$E = M_{v_1}{C_r}^2 + M_{v_1}V^2 = M_{v_1}(c^2 - v^2) + M_{v_1}(v - v_1)^2 \tag{123}$$

✧ **In the co-moving frame**

In the case of a co-moving frame, that is, $v_1 = v$ and $V = 0$, Eq. (123) becomes as follows.

$$E = M{C_r}^2 + MV^2 = M(c^2 - v^2) = mc^2 \tag{124}$$

Since the total energy is the same in the both frames, the intrinsic energy M in the co-moving frame is given as follows.

$$M = \frac{m}{1 - v^2/c^2} \tag{125}$$

This is the same as Eq. (86), which was discussed on the acceleration. The moving speed of the intrinsic energy M is not the light speed but is $\sqrt{c^2 - v^2}$. Therefore, the fundamental force constant K_f for the light speed c of intrinsic energies cannot be used for M. We use the term "mass" for such intrinsic energies that move at c. M is not a mass, and we call it just as an intrinsic energy. If we use this intrinsic energy M, the equation of motion is given by

$$F = M\alpha\,. \tag{126}$$

The intrinsic energy M in the co-moving frame shows the nature of resistance to be accelerated, but it varies by the moving velocity v.

✧ In a general moving frame

In a general moving frame including the case of $v_1 \neq v$, the energy is expressed by Eq. (123). The energy motion is expressed as follows.

$$E = M_{v_1}\left({C_r}^2 + V^2\right) \tag{127}$$

$$V = v - v_1 \tag{128}$$

$${C_r}^2 = c^2 - v^2 = c^2 - (V + v_1)^2 \tag{129}$$

Eq. (128) for the linear velocity is valid also for the light speed. If we include any angle θ between $\mathbf{V}$ and $\mathbf{v_1}$, the light speed $C(\theta)$ is given as below.

$$C(\theta) = c - v_1 \cos\theta \ , \qquad -\pi \leq \theta \leq \pi \tag{130}$$

This shows the anisotropy of light speed. If $|\theta| < \pi/2$, $C(\theta)$ is smaller than c, and if $|\theta| > \pi/2$, $C(\theta)$ is greater than c. In our actual observations, it is difficult to measure v_1 or v. We detect V and E. If v_1 is extremely smaller enough than c, we may approximate Eq. (127) as if it were in the stationary frame as follows.

$$E \approx m(c^2 - V^2) + mV^2 = mc^2 \tag{131}$$

The energy of Eq. (127) is equal to that in the stationary frame. There is the following relation.

$$E = M_{v_1}\left({C_r}^2 + V^2\right) = M_{v_1}(c^2 - (V + v_1)^2 + V^2) = mc^2 \tag{132}$$

$$M_{v_1} = \frac{c^2}{c^2 - 2v_1V - {v_1}^2}m = \frac{c^2}{c^2 - 2v_1v + {v_1}^2}m \tag{133}$$

If $v_1 = v$, $V = 0$ and M_{v_1} becomes M for the co-moving frame shown by Eq. (125).

Conclusion

✧ Equations of summary

Let me summarize the novel dynamics by the ECT in the following equations.

a) Expression of energies

Energy of a static particle without a force: $E = mc^2$

$E(x)$: Energy of the particle under a force $F(x)$, which is zero at $x = \infty$.

Potential energy (definition):

$$E_p(x) \equiv \int_{\infty}^{x} \big(-F(x)\big)dx$$

Rest energy (definition): $E_r(x) \equiv E(x) - E_k(x) = mc^2 + E_p(x)$

(1) In a free motion for the whole region where the force acts

(Acceleration by a force acting for a short distance)

Kinetic energy: $E_k(x) = -E_p(x)$

Rest energy: $E_r(x) = mc^2 + E_p(x)$

Total energy: $E(x) = E_r(x) + E_k(x) = mc^2$

Linear energy: $E_L(x) = mv^2$ (v: function of x)

Circular energy: $E_c(x) = m{C_r}^2 = m(c^2 - v^2)$

Total energy: $E(x) = E_c(x) + E_L(x) = mc^2$

(2) Static at $x = x_1$, then starts a free motion

Total energy at x_1: $E(x_1) = mc^2 + E_p(x_1) \equiv m_1c^2$

Rest energy: $E_r(x) = mc^2 + E_p(x)$

Kinetic energy: $E_k(x) = E_p(x_1) - E_p(x)$

Total energy: $E(x) = E_r(x) + E_k(x) = mc^2 + E_p(x_1) = m_1c^2$

Helical expression: $E(x) = E_c(x) + E_L(x) = m_1\big({C_r}^2 + v^2\big) = m_1c^2$

b) Equation of motion

$$\mathbf{F} = \frac{m}{1 - v^2/c^2}\boldsymbol{\alpha} = \frac{m}{1 - v^2/c^2}\frac{d\mathbf{v}}{dt}$$

c) Kinetic energy

$$E_k = -\frac{mc^2}{2}\log\left(1 - \frac{v^2}{c^2}\right) = \frac{1}{2}mv^2\left(1 + \frac{1}{2}\frac{v^2}{c^2} + \frac{1}{3}\frac{v^4}{c^4} + \frac{1}{4}\frac{v^6}{c^6} + \cdots\right)$$

✧ Concluding remarks

Thus, we have seen in this book the new understandings of dynamics completely different from the standard physics. The most important claim on dynamics from the ECT is the novel equation of motion of Eq. (84). It replaces the Newtonian equation of motion. It is different from the relativistic mass by the special relativity, too. If the initial speed is zero, the acceleration by the same force is inversely proportional to the mass. But in the case of a moving particle, the acceleration varies by its velocity.

The other important insight claimed in this book is the clarification of the potential energy and the kinetic energy discussed in the Chapter 9. The potential energy was defined clearly. The concept of free motion was expanded to acceleration by any force, even which works only for an instance, not only under a continuous force like the gravity. If it is in a free motion for the whole range, the sum of kinetic and potential energies of any particle is zero. When it is accelerated, its potential energy is decreased. This is applied also for acceleration by a mechanical force acting only for a short time. If a particle is static under receiving a continuous force, the total energy is equal to the rest energy, but in which the potential energy is incorporated.

Any observable energy (apparent energy) should be moving in the space energy, and cannot be static. However, by forming an energy circulation by the fundamental force, it can be static to the space energy, and shows the property as a particle. To express the same particle, we can take many combinations of an intrinsic energy and its velocity; small intrinsic energy with high speed, or large energy with slow speed. The fundamental force works on momentums, which differ by the velocity. Therefore, the fundamental force constant also differs by the velocity of intrinsic energies. If we use such intrinsic energies of a common velocity, the momentum becomes proportional to the energy, and the force constant becomes invariant. We defined the mass as an intrinsic energy that is moving at the light speed. Thus, the energy of a particle is given by $E = mc^2$.

The special relativity (SR) insists that the rest mass is invariant by any frames to measure. The rest mass is simply called as mass. However, there is no rationale to support the invariance of rest mass. By a change of a frame to measure, the total energy should be unchanged. The premises of the SR do not hold as the starting points.

The SR also claims that the rest mass of a particle is invariant by the altitudes from the ground level. It is said in general that the adjustment of the clock frequency of atomic clocks on satellites is a supporting evidence of the general relativity. However, it is wrong. The higher frequency of clocks on satellites is due to the increase in their energy by the gravitational potential energy.

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