# The 5th Dimension

# Dawning of the Force of Gravity

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Shigeto Nagao

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## 1. Prologue: the 5th Dimension

Do you remember "the 5th Dimension", one of the most popular music groups in late 1960s? A hit song of them is "Aquarius – Let the sun shine", which sings "When the moon is in the seventh house, and Jupiter aligns with Mars, ------ This is the dawning of the age of Aquarius".

When I was a high school boy, I went to a concert of the 5th Dimension at the EXPO 1970 in Osaka. 55 years later, the word "fifth dimension" opens up a clue to elucidate the gravitational force. Is this a coincidence, or fate? Let me introduce a dreamlike tale of the boy.

After visiting several ones, I lastly entered to the Indian pavilion. I felt something discomfort then in the EXPO 1970. Everybody praised it as joyful and successful, but it seemed superficial to me. I met a mysteriously beautiful Indian stuff there, and took a photograph of her and me. Soon after passed by, I wrote a message on a piece of paper, turned around, and returned to her. I handed it over. It said, "I would like to send you a photo of you, so could you please write down your address?" I added one sentence, "If you don't, I will die." She laughed in surprise and said "You will die?".

Then our correspondence by letters started. With English dictionaries in hand, I did my best to convey the reality of a high school boy like me. She also openly wrote about her hometown, family, and various matters happed in Japan. I visited the Indian pavilion many times to see her. There was a serious problem. Even if I could correspond in writing but could not converse in English. I quickly started to study English conversation by TV, radio, and books. Until I met her, I had hated the Englich class. Communication in English with her became my biggest goal.

Having tea and samosa at the cafeteria in the pavilion, she kindly talked to me various things. For instance, she showed a ring on her left ring finger, and said it was to ward off approaches from many Japanese men.

I invited her to the 5th Dimension's concert in the Expo. I booked two seats. I went to the pavilion at the time we promised. However, I could not find her there. I got at a loss, but I spoke to a colleague of her there, and explained the situation. I heard a worst word that she caught a cold and was absent from work. But her colleague added, "why don't you come to her apartment". They lived at an apartment together by three. She took me there, and my friend was on the bed. She asked her colleague to go to the concert with me. Everything happed on the day was really dreamlike. The 5th Dimension on the stage was amazing that night.

In the year 2025, now that the EXPO is being held again in Osaka, another "fifth dimension" came up to me.

## 2. Too many open questions in the standard physics

In 1997, startling news spread in the world that the expansion of the universe is accelerating. The Supernova Cosmology Project released an interim-result from the observation of supernovae. It had been expected that the space expansion would be slowed down due to the gravitational force, but it is accelerating. In 1999, the first full paper was published. Almost all physicists agreed with their conclusion of the accelerating space expansion. However, the conclusion is based on the condition that the light speed has been constant from the big bang to the present. If the light speed has been getting slower by time, the supernova data do not show the acceleration.

In order to explain the acceleration, physicists insist that there should be an unknown energy, called dark energy, that causes repulsion (or negative pressure) and accelerates the expansion. It is unknown at all what is dark energy in fact.

Has the light speed really been constant? The light speed invariance was concluded from the Michelson-Morley (MM) experiment conducted in late 19$^{th}$ century. Similar experiments were carried out many times over 100 years. The light speed invariance is believed to be an absolute truth experimentally proved. All of the MM-like experiments tried to measure a difference in frequency between two directional beams either as a change in infringe pattern or in difference frequency (beat note). Even if the light speeds are different between two directions, since the beams are led to the same direction to the detector, their speeds become the same. I demonstrated and reported that the MM-like experiment can measure a change in brightness of the combined wave but cannot detect a change in frequency. I had several chances to ask professional physicists about the measurement principle of the MM-like experiments, but no one could answer sufficiently. They only argued that the light speed invariance has been proved repeatedly by many experiments. They accept the conclusion without checking the experimental principle by themselves since it is widely said to be correct.

From the light speed invariance (or isotropy), the Lorentz transformation between different moving frames was proposed, which is the core of the special relativity. The starting point for the special relativity has not been proved, and may be wrong. The interpretation of dark energy from the supernova data is lack of proved basis.

Similar situations are seen not only in the special relativity and dark energy but in almost all of so-called the modern physics; quantum mechanics, particle physics, and standard model of cosmology. Does a

particle really consist of quarks? Does a black hole really exist? Does dark matter really exist? There are too many serious open questions, which the standard physics cannot explain. However, they say that their physics are correct and that only those are unknown or not yet discovered.

In order to seek for real natures of physics, we have to once abandon the existing concepts, which are believed to have been proved, I strongly felt.

I firstly thought that everything either particle or light can be reduced to energy. The energy should be vibrating. In order to vibrate, energy needs a medium. Further, for a medium to vibrate, there should be a tension or force enabling the vibration. I expected that the space of universe is filled with energy, and its vibrations render additional energies, which are our observable energies.

It was an extremely tough question for me what would be the force that can allow the medium to vibrate. I started to privately investigate the physics in 2007. Eleven years later in 2018, I reached and reported a completely new physical system called as the **energy circulation theory** (**ECT**). The ECT is a logical development from two premises to elucidate the cosmic evolution from scratch, with setting aside all contents of existing physics once. Let me briefly introduce the basis of the ECT

## 3. Premises of the Energy Circulation Theory

First, I defined the **energy** as "**anything that exists in the universe**", and that it vibrates in multiple dimensions while we do not know the number of the dimensions. Then, the distributions and interactions of energy give other physical properties. This definition is the exact opposite of that in the

existing physics. In the standard physics, energy is defined secondarily from such as mass, electric charge, and velocity.

The starting premises of the ECT are not to discuss right or wrong. The ECT is to logically develop what can be said from these premises. I expected that an energy movement vests an additional energy and that an energy can be expressed by an intrinsic energy and its velocity, then set the following as the first premise.

> **Premise** (1): Energy can be expressed by the **product** of an **intrinsic energy** and the **square of its velocity**.

$$E = M_1{V_1}^2 = M_2{V_2}^2 = mc^2 \tag{1}$$

There are many ways to select the intrinsic energy, but in all combinations, the product of the magnitude of the intrinsic energy and the square of its velocity gives the same energy. The energy based on the motion in the directions orthogonal to the target direction acts as the intrinsic energy, which is moving in the target direction.

We define the "**momentum**" as the product of an intrinsic energy and its velocity.

$$\mathbf{p} \equiv M\mathbf{V} \tag{2}$$

The amount of energy does not depend on the selection of the intrinsic energy, but the momentum alters by that. If we adopt such intrinsic energies that move at a common velocity, the momentum gets proportional to the energy. An intrinsic energy has the property of mass, but we define such **intrinsic energies** that **move at the light speed $c$** as the "**mass**" in the narrow sense. For instance, an energy that moves at a velocity $v_x$ in the direction $x$ can be expressed as the intrinsic energy $M$ is moving at $v_x$, but in the same time we can also express it as the intrinsic energy $m$ is **helically moving at the light speed $c$** with circulating in the $yz$ plane.

$$E = M{v_x}^2 = mc^2 = m\left({v_x}^2 + {v_{yz}}^2\right) \tag{3}$$

The momentum of the mass $m$ in the direction $x$ is as follows.

$$\mathbf{p_x} = m\mathbf{v_x} \tag{4}$$

In the standard physics, the mass is not clearly defined. In the ECT, the mass is clearly defined as above explained, and the meaning of $E = mc^2$ has been also made clear. This equation is to express the energy by using the intrinsic energy (mass) moving at the light speed $c$.

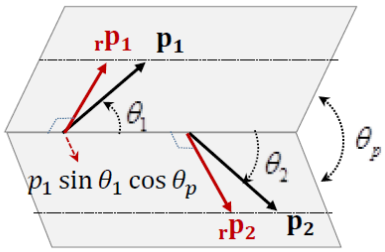
The second premise of the ECT is that there works a force based on momentums.

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

$$F = K_f \frac{\mathbf{_rp_1} \cdot \mathbf{_rp_2}}{d^2} = K_f \frac{p_1 p_2}{d^2} \cos\theta_p \sin\theta_1 \sin\theta_2 \tag{5}$$

$K_f$ : Fundamental force constant

**Fig. 1. Momentum components to the distance**




I named this force as the "**fundamental force**". The charge that exerts a force is a momentum, which is a vector having a direction. Therefore, the equation (5) has three angular factors in addition to the distance. As shown in Fig. 1, $\mathbf{_rp}$ 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 $_rp = p\sin\theta$. 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**.

The equation (5) may seem difficult but it implies that two energies moving in opposite directions attract each other and those moving in the same direction repel each other. If the conditions are right, anti-parallel energy movements turn to circulate by the attractive force due to the fundamental force, and form an energy circulation. The "**energy circulation**" here shall be what in which the intrinsic energy is distributed even and continuously on the circumference. A local energy on the circumference shows a centripetal force by receiving the fundamental force from the energy of the whole circulation. I named this force as the "**intra-circulation force**". The formula to show the intra-circulation force has been derived from the equation (5). This force is determined by the **radius** and the **whole circular momentum** of the **circulation**. It has been also found that the **radius** of an energy circulation is **proportional** to the **amount of its energy** as the intra-circulation force is balanced with the centrifugal force.

The **inter-circulation force** that acts between two energy circulations has been also derived from the equation (5) of the fundamental force. In the inter-circulation forces, there are the flat interaction within the same plane and the orthogonal interaction in perpendicular directions. Furthermore, the sign of the force is reversed depending on whether the circulation directions are the same or opposite.

The energy circulation, (1) keeps a constant radius proportional to the energy amount by the intra-circulation force, and (2) exhibits interactions with other energy circulations due to the inter-circulation forces working between different circulations. These properties exactly show the nature of a particle. In the ECT, the "**particle**" is defined as an **energy circulation**.

Can you feel the difference between the energy and the particle? In the standard physics, the two terms are not clearly defined, but allow them to convert to the other very conveniently. Everything that exists is an energy. Any energy is a continuum vibrating in multiple dimensions. Basically, an energy cannot be static, but if it forms a circulation, it can be at rest.

## 4. Outcomes from the ECT

We divide the cosmic energy to two parts. The **space energy** is the symmetric part, and is the energy of the vacuum space. It functions as the medium for the **apparent energy**, which is the asymmetric part of the cosmic energy and our observable energies like light and particles. What I explained in the previous section holds true for both the whole cosmic energy and the apparent energy.

It should be tough for you to believe, but the ECT has successfully solved most of open questions in the standard physics, such as on dark energy, dark matter, gamma-ray bursts, large-scale structures of universe, formation of various shapes of galaxies. The ECT also renewed the particle physics and electromagnetism.

For instance, on the light speed invariance that we discussed in Section 2, the ECT successfully derived the equation of the light speed with the variable of the cosmic radius. As the space expands, the light speed has been decreasing due to the reduction in density of the medium (space energy). The Hubble diagram (brightness versus redshift of lights from stars), which was derived from the light speed equation, showed an excellent fit to the observed data of supernovae. The space expansion is not accelerating.

Another example is a disc galaxy. In the standard physics, they expect a super-massive black hole at the center to explain the concentric distribution of circulating stars. Without such a black hole, the gravitational force is insufficient for the rotating structure. The rotating velocities of a disc are almost the same at any radial distances. From the balance between the gravitational force and the centrifugal force, the rotating speed should be faster at short distances than large ones. They introduced the existence of dark matter above and below the disc to solve this problem. However, dark matter has not been discovered. According to the ECT, the centripetal force is not the gravitational force but the fundamental force much stronger. Without a black hole, such a thin and concentric structure of a disc galaxy is formed. Furthermore, the rotating velocities are the same at any radial distances without expecting dark matter, the ECT proved.

## 5. Missing piece to completing the ECT

The gravitational force works based on the amount of energy. On the other hand, the fundamental force acts on the momentum, that is, the movement of energy. Here arises an ultimate **question**:

**Is the gravitational force derived from the fundamental force, or does it exist independently as a law?**

Since I released the ECT, I was repeatedly thinking of this question. However, I could not reach a conclusion. I had expected that the gravitational force would be derived from the fundamental force, this was the reason why I named the force working on momentums as the fundamental force. However, I failed such a derivation. Then, I left the gravitational force as to work as a law.

Here, let me introduce the forces controlling the motions of celestial bodies. In the standard physics, it is believed that only the gravitational force controls them. However, from the ECT, both forces control their motions.

As explained in p8, within an energy circulation, the intra-circulation force works by the fundamental force. Not only within a continuous energy circulation, an attractive force from the fundamental force acts within a cluster of energy circulations in a ring shape. We call it as the **intra-ring force**. In the case of energy circulation, the radius takes a constant value due to the balance with the centrifugal force. However, since such a ring is not a continuum, its radius can continuously increase as the space expands. Individual members of the ring continue to circulate and show a spiral motion. Their circular velocity is kept as invariant even if the radius increases.

An early-stage huge energy circulation decomposed to local circulations simultaneously on the whole circumference. We call it as the **cyclic decomposition**. The cyclic decomposition repeated in many rounds, resulting in innumerous number of the **galactic seed**, which is a continuous energy circulation and will develop to a galaxy. Thus, a **hierarchal structure of rings with multiple generations** were formed such as clusters of galaxies, super clusters, and higher-level ones. All rings of galaxies of any generations are rotating. The **motions of galaxies** are **controlled by the fundamental force** as intra-ring interactions.

As the space expands, a galactic seed started to release its daughter circulations called the **stellar seeds**. There are two types of stellar seed releases. Stellar seeds are released simultaneously on the whole circumference; this is the **ring release**. It happens intermittently and results in a rotating disc galaxy consisting of concentric rings. Independent releases happen rather continuously and stellar seeds move linearly; this is

called as the **linear release**. The **force controlling the motions of fixed stars** in a rotating galaxy is the **fundamental force** as intra-ring interactions.

In a stellar system, planets and comets are individually orbiting. They are not in a ring structure around the star. Therefore, the fundamental force does not act on them. The **motions of planets** within a stellar system are **controlled by the gravitational force**.

We can summarize that the controlling force of motion is the fundamental force for galaxies, mainly the fundamental force for fixed stars in a galaxy (gravitational force for those in a non-rotating galaxy) , and the gravitational force for planets and comets in a stellar system.

## 6. Fifth dimension

After the first release of the ECT in 2018, the ECT has brought about miracle successes in most areas of physics. However, the last piece is missing, that is the ultimate question on the gravitational force; is it derived from the fundamental force or does it exist independently as a law? I have been struggling with this question already for seven years. I have been almost given up to solve this question.

This year, the EXPO 2025 is being held in Osaka. I watched on TV various pavilions and events, and it brought back my memories of the EXPO 1970 including what happened on the day of the concert of the 5$^{th}$ Dimension.

I think it was in June, and the following words suddenly came up to my brain.

"*I have been missing a very important point. Yes, it is the **fifth dimension** in the **cosmic separation**.*"

I used to well recognize that an energy circulation has a 3D structure while it can be expressed in 2D. The intrinsic energy has a local circulation in orthogonal to the main circulation, and shows a helical motion in total in the 3D expression. However, I did miss the fact that the **orthogonal direction** of one of conjugate pairs of energy circulations in the cosmic separation to two universes is not included in the four dimensions to be expanded. It may have been my simple oversight. I named this orthogonal direction as the "**Fifth dimension**", which actually led me to the dawning of elucidating the gravitational force.

I immediately started writing an article, and the paper with the title of "the origin of the gravitational force - derivation from the fundamental force" has been published recently.

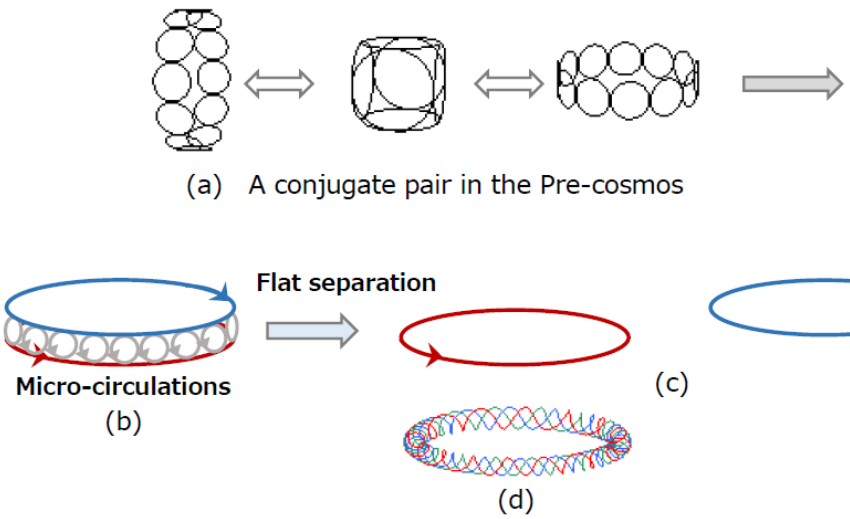
Here, let me introduce the first process of the cosmic evolution; the **cosmic separation**. So that your readers can feel a logical development to the gravitational force, I will explain it rather in detail. But I hope you will enjoy the discovery of the Fifth dimension.

## 7. Cosmic separation

At the initial stage called as the "**pre-cosmos**", all energies were symmetric. Energy is a vibration in multiple ($M$) dimensions, while we do not know the number $M$ yet. The energy of the pre-cosmos can be expressed as an assembly of coupled pairs of conjugate circulations in dimensions of $X_1$-$X_2$, $X_3$-$X_4$, $X_5$-$X_6$ --- and $X_{M-1}X_M$. Each pair is an adduct of two circulations with opposite circular directions. Let us call it as a **conjugate pair** of circulations or a **double circulation**, whose circular momentums are cancelled out to be zero, and the fundamental force does not work on it.

Fig. 2(b) shows the structure of a conjugate pair (double circulation). The orthogonal distance between the two conjugate circulations cannot be zero but show a certain minimum value by forming the **micro-circulations** with the circumference direction. Fig. 2(a) shows a conjugate pair in the pre-cosmos. Within a threshold value of radii, the main circulation and the micro-circulations can flexibly change radii and directions in the three dimensions.

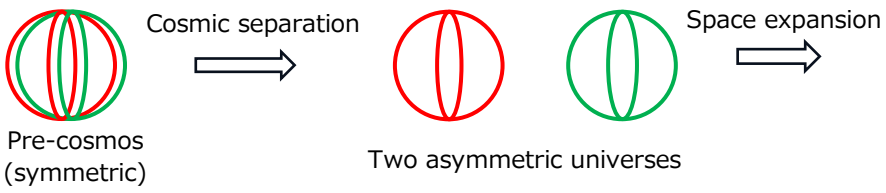
**Fig. 2. Conjugate pair in the Pre-cosmos and its flat separation**




If the amplitude (radius) of any one dimension ($X_1$) gets larger than the threshold, conjugate circulations separate in two pairs including $X_1$. One is the pair including $X_1$ in the main circulation in $X_1$-$X_2$. It occurs the flat separation from (b) to (c) in Fig. 2. The second pair in $X_3$-$X_4$, whose orthogonal direction is $X_1$, separates orthogonally. Thus, four dimensions $X_1$, $X_2$, $X_3$, and $X_4$ get asymmetric, that is, show circular momentums. We call this process as the **cosmic separation**. Its 3D image is shown in Fig. 3, while the real is in 4D. The pre-cosmos divides to two universes, whose

symmetric properties are opposite to each other. In each one of the micro-circulations shown in Fig. 2(b), the intra-circulation force was balanced with the centrifugal force. Since the micro-circulations were broken by the separation, the radii of the resulted single circulations started to expand rapidly. This is the **space expansion**.

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




Please come back to Fig. 2. The orthogonal direction of the conjugate pair in $X_3$-$X_4$ is $X_1$. Then, what is the orthogonal direction of the other conjugate pair in $X_1$-$X_2$, which will arouse a flat separation? This point is exactly **what I missed** until now. I named it as the **Fifth dimension** shown by **$X_5$**. After the break of the micro-circulations, the momentum in the local circulation including $X_5$ has remained in each universe to the present. There affects a force between two momentums in $X_5$, this should be the gravitational force.

## 8. Evolution of a 4D spherical universe

Since the cosmic separation, 4 dimensions have been expanding. The energy distribution (= space of universe) is on a 3D surface of a sphere in 4D, which we call as the **4D spherical universe**. The 3D surface called as the **space dimensions** have been immensely expanded. However, in the radial direction called as the **hidden dimension** , the energy resides only in

one very thin layer of the constant radius $\mu_0$. The 4D sphere of the radius $\mu_0$ is the minimum unit of the space, and the space energy there is defined as the **spacia**. The entire space is filled with the space energy, whose minimum unit is the spacia, and its vibrations give the apparent energy, which we can observe.

As explained on p11, multiple-round cyclic decompositions of early circulations gave the galactic seeds, from which stellar seeds were released. Each stellar seed released daughter circulations, which further decomposed to smaller circulations. The smallest quantized energy circulation is the **elementary single circulation**, whose radius is equal to the radius $\mu_0$ of the spacia. There are two types of elementary single circulations; $S$ in space-space dimensions and $iS$ in hidden-space dimensions. A conjugate pair of single circulations is the **elementary double circulation**; $D$ or $iD$. A composition of elementary circulations (single, double, or excited form) in a single spacia is defined as the **quantum particle**, such as mesons and baryons.

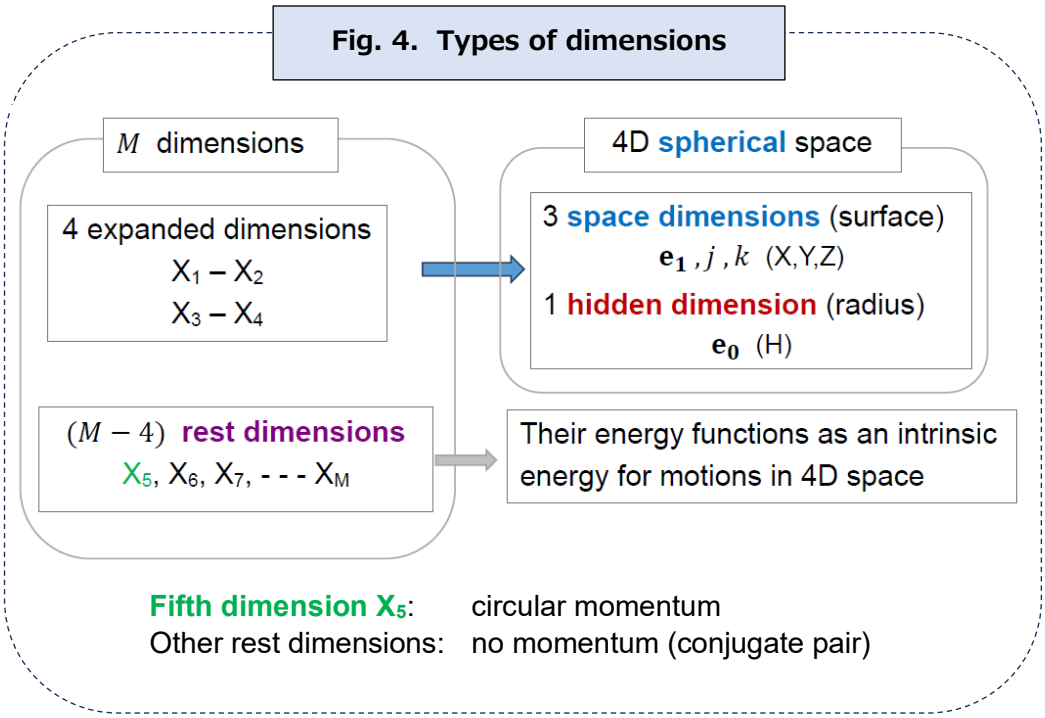
Let us take a quantum particle of the intrinsic energy (mass) of $m$. It is an energy circulation with the radius $\mu_0$, and has the energy $E = mc^2$. $m$ is circulating at the light speed $c = \mu_0\omega_0$, where $\omega_0$ is the angular frequency. How does the intrinsic energy $m$ come from? It is derived from motions in the **rest dimensions**, which are defined as the **other dimensions than the 4 expanded ones**. The energies of the motions in the rest dimensions are incorporated in the intrinsic energy for motions in the 4D space. There is the following relation.

$$E = mc^2\,, \qquad m = m_r c^2 = m_5 c^2 + m_{od} c^2 \tag{6}$$

Among the energies in the rest dimensions, only that in the Fifth dimension $X_5$ has a circular momentum. Circulations in other rest dimensions form a conjugate pair and their momentums are cancelled out. $E_5 = m_5 c^2$ is the

energy from the circulation including $X_5$, and $m_{od}c^2$ is that in the other rest dimensions.

Up to here, many dimensions came out. Let us summarize them in Fig. 4.




## 9. Gravitational force

We **define** the **gravitational force** as:

the **fundamental force** between momentums in the **Fifth dimension**.

Based on this definition, let us see some examples of the gravitational force.

Firstly, let us divide a quantum particle of the mass $m$ to two halves. Between the two half-circle momentums, the following fundamental force acts from Eq. (5) if we use the approximation to treat their circular momentums as linear.

$$F \approx K_f \frac{(mc/2)(-mc/2)}{(2\mu_0)^2} = -K_f \frac{(mc/2)^2}{(2\mu_0)^2} \tag{7}$$

The gravitational force between the same two halves is given as below.

$$F_g \approx -K_f \frac{(m_5 c/2)^2}{(2\mu_0)^2} \tag{8}$$

Between $m$ and $m_5$, the relation of Eq. (6) exists. At least we can say $m > m_5 c^2$. We get a rough ratio of potency between the two forces as follows.

$$\frac{F_g}{F} < \frac{1}{c^4} \approx 10^{-34} \tag{9}$$

A typical example of this fundamental force is the electric force within the elementary single circulation $iS$. The gravitational force is **so weak as $10^{-34}$ times** of the electric force. The gravitational constant $G$ is derived from Eqs. (6) and (8) accurately without using an approximation. The gravitational force in this case is finally given as follows using $m$.

$$F_g = -G \frac{(m/2)^2}{(2\mu_0)^2} \tag{10}$$

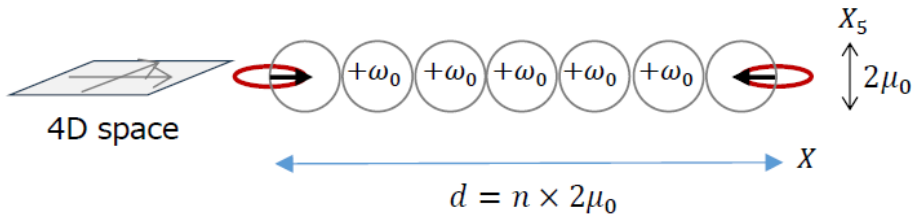
This is exactly the same as the Newton's equation of gravity for this case.

## 10. Gravitational force between two static particles

Let us see the gravitational force between two quantum particles of the mass $m$ at rest. Fig. 5 is the most important key figure to explain the gravitational force. The horizontal plain shows the 4D space, in which the intrinsic energy $m$ of the particle is circulating as shown by the red circle (can be a complex of plural circulations in the 4D). I named the circulation in $X_5$ and the distance direction X as the **g-circulation**. Between any intrinsic energies, a series of g-circulations are connected, which we call as the **g-chain**. The g-circulations are in a vertical direction to the 4D space

and the distance direction, and their radius is $\mu_0$ equal to that of the spacia. The 4D-space location of the g-circulation in Fig. 5 shows the average.

**Fig. 5. The g-chain consisting of connected g-circulations between two quantum particles**




The internal circulations of the particles are in the 4D space. The g-circulations are in the fifth dimension $X_5$ and the distance direction $X$. The two black arrows show the attractive gravitational force acting on the particles.

The intrinsic energy $m_5$ is circulating at the light speed $c = \mu_0\omega_0$, where $\mu_0$ is the radius and $\omega_0$ is the angular frequency. A half-circle momentum of the g-circulation corresponds to the mass $m$ of the particle. Therefore, the gravitational force in the case of $n = 1$, in which two particles are adjacent, is given as follows from Eqs. (8) and (10).

$$F_g(n = 1) = -G\frac{m^2}{(2\mu_0)^2} \tag{11}$$

The distance between the two particles is $n$ times of the diameter $2\mu_0$. The energy of a g-chain shows its gravitational potential energy. It depends on the distance. However, in practical cases of distances greater than an atomic size, the number $n$ of g-circulations is greater than $10^4$, and the energy of the g-chain at such distances has reached almost the maximum, which is that at $d = \infty$. Therefore, we can treat the **energy of a g-chain** as **constant** for distances greater than an atomic size. The gravitational force on one particle is derived from one g-circulation, whose energy is **$1/n$ times**

that of the case of $n = 1$. We get the following formula as the gravitational force.

$$F_g(n) = -G\frac{(m/n)^2}{(2\mu_0)^2} = -G\frac{m^2}{(n \times 2\mu_0)^2} = -G\frac{m^2}{d^2} \tag{12}$$

Thus, we have got the relation that the gravitational force is **inversely proportional** to the **square of the distance**. Why the gravitational force is **only attractive** is because it is an **intra-circulation force**. There is no chance of being repulsive.

Between two quantum particles of different masses, the relation of Eq. (12) holds. The force is a vector having a direction. The gravitational force on a quantum particle with a cluster of many particles is given by a vector sum of individual forces. Between any objects of masses; $m_1$ and $m_2$, the following force acts.

$$F_g = -G\frac{m_1 m_2}{d^2} \tag{13}$$

This is exactly the Newton's equation of gravity.

## 11. Gravitational force under the free motion

The discussions in the previous section are on two **static** particles. However, by the gravitational interaction, the particles are to be accelerated under the free motion. The **free motion** is a wider concept than the free fall, and is defined as that the object is freely accelerated by receiving a force.

As shown in Fig. 1, the fundamental force acts on the **orthogonal** component $_r\boldsymbol{p}$ of the momentum to the distance direction. The gravitational charge causing the gravitational force is primarily the momentum in the Fifth dimension, but it appears as the mass (scalar without a direction) in the 3D space. If the particle is at rest, the mass of the total energy is the gravitational charge. However, under the free motion, it is to be accelerated

in the force direction. The effective component energy is that derived from motions in orthogonal directions. Let us call the effective energy as the "**orthogonal energy**" and its mass as the "**orthogonal mass**" shown by ${}_r\boldsymbol{m}$. Let $v$ be the velocity in the distance (force) direction. The orthogonal mass is given as follows, where the intrinsic energy $m$ is helically moving.

$$E = mc^2 = mv^2 + m(c^2 - v^2) = mv^2 + {}_rmc^2 \tag{14}$$

$${}_rm = m\left(1 - \frac{v^2}{c^2}\right) \tag{15}$$

Finally, we obtain the general formula of the gravitational force as below.

$$F_g = -G\frac{{}_rm_1 \cdot {}_rm_2}{d^2} \tag{16}$$

In the case of light, $v = c$ and the orthogonal mass is zero in the traveling direction. However, in an orthogonal direction to the traveling one, the total energy of the light becomes the orthogonal energy. That is, the magnitude of the speed of light does not change when it receives a gravitational force, but the direction of propagation changes if the force is perpendicular.

## 12. Closing

In this book, I have been trying to show how the gravitational force is derived from the fundamental force. Though the explanations were rather long and complex, could you feel some consent of the possibility?

I conclude that the gravitational force is the fundamental force working on momentums in the Fifth dimension. The charge for the gravitational force comes out as the mass in the 3D space. Let me summarize what the study this time has achieved, which were left as unsolved open questions in the standard physics.

(1) Revealed the origin of the gravitational force, and demonstrated that all forces including the gravitational one are outcomes of the fundamental force.
(2) Proved why the gravitational force is only attractive.
(3) Quantitatively derived that the gravitational force is as potent as $10^{-34}$ times that of the electric force.

Lastly, let me close this booklet with my faint hope. I wonder if I could have a chance to meet the Indian lady again and share our story over 55 years from the EXPO 1970, through the fifth dimension, to the gravitational force.

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Shigeto Nagao

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