Nature of the time and
4D Spherical Model of the universe
- Part 1 –

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What is the nature of the time? What is difference of the time dimension from a space dimension? After investigating requirements for a dimension to work as a time, we propose a 4-dimensional spherical model of the time and universe starting from that energy is a vibration in multiple dimensions.

< Part 1 >

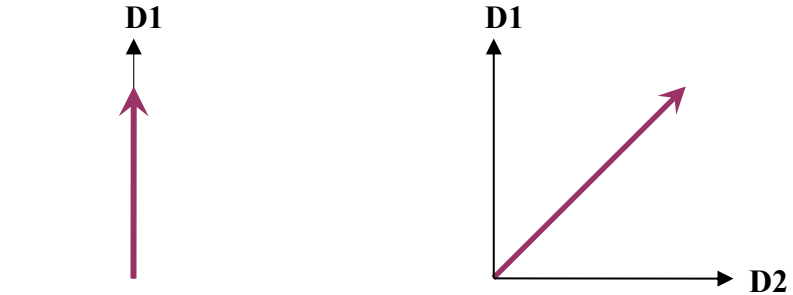
1. **Nature of the time**
2. **4D Spherical Model of the universe**
3. **Michelson-Morley experiment**
4. **Acceleration factor** for propagation of a stationary wave in its wave medium: movement of energy in the 3-D space
5. **Expansion of the universe**

< Part 2 >

6. Light speed **7. Redshift** **8. Light propagated distance**

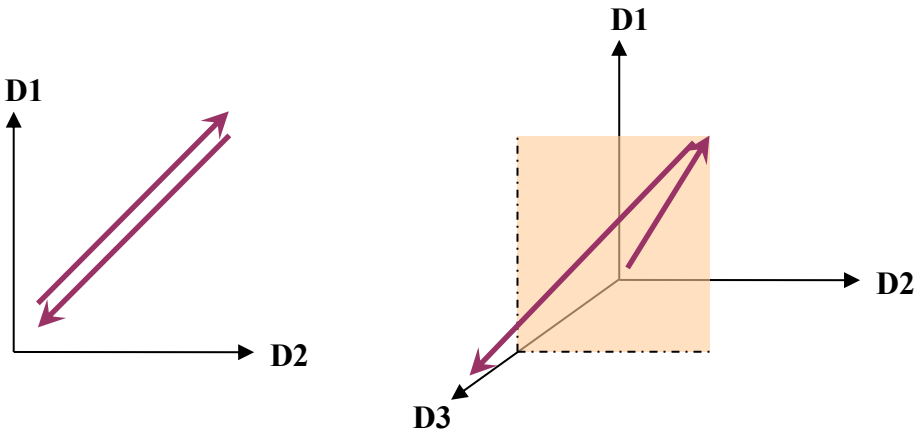
1. Nature of the time - Tracing dimension

For expressing a **movement** (value change), another dimension to **trace** it is essential.



To express a movement in 1-D (D1):

A Tracing dimension (D2) is essential



To express a movement in 2-D (D1-D2):

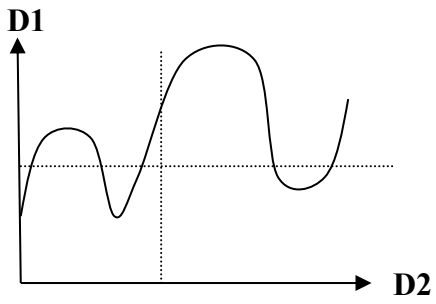
Another tracing dimension (D3) is required.

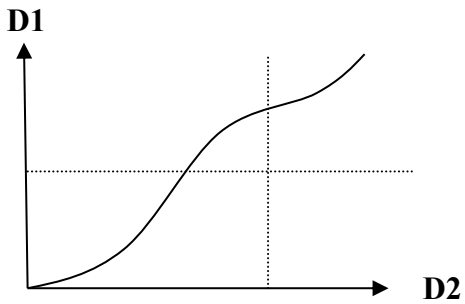
Define the "***Tracing dimension***" as a dimension, by variance of which a value-change (movement) of the resting other dimensions is expressed.

Conditions of a Tracing dimension

1) To work as a Tracing dimension, any single value of it should correspond to a single value of any resting dimension for a movement.

2) If respective values of two (plural) dimensions vary on one-to-one correspondence, either dimension can be a Tracing dimension to the other.





3) For plural movements, a Tracing dimension should comply with the requirement 1) for all of them.

Imaginary order of freedom

When traced by another dimension

Order of freedom of Y:	**1st order**	**0 – order**	**Imaginary order**
Value:	**Chance to select (or plural values)**	**Constant**	**Moving single value**

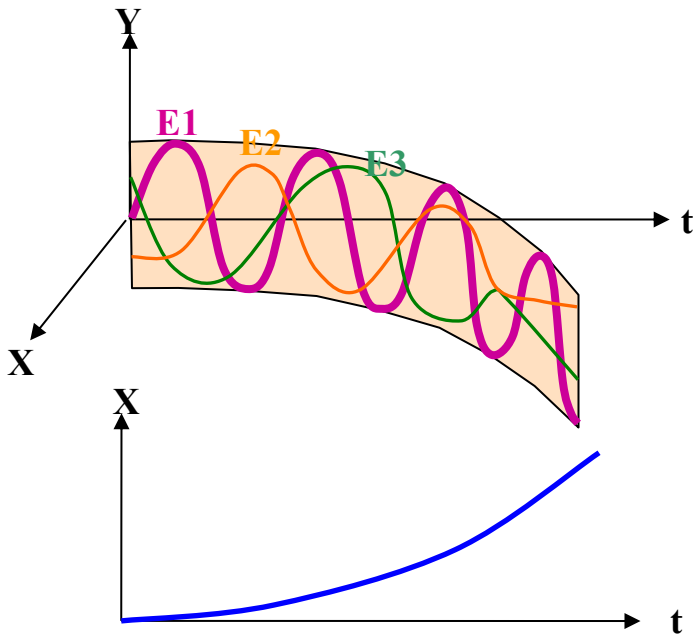
Define the "***Imaginary order of freedom***" as follows:

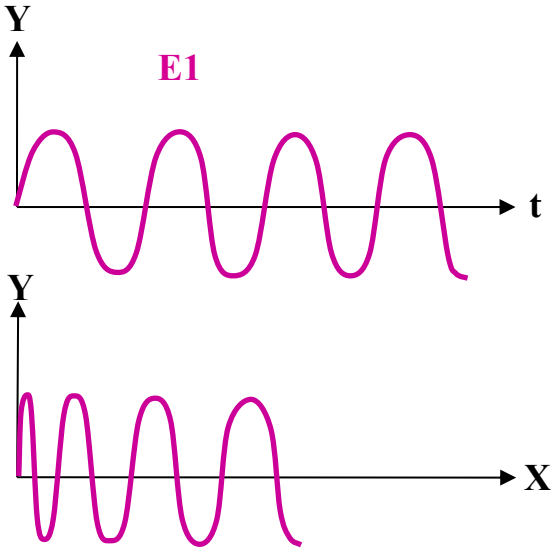
- There is no freedom of selecting a value, and furthermore,
- the value is not a constant but moving in a single direction (increase or decrease).

Imaginary order of freedom and Tracing dimension

Traced by t: **Y** = 1st order of freedom, **X** = imaginary order of freedom

X can also act as a tracing dimension for **Y**.





A dimension showing ***imaginary order of freedom*** can be an **alternative *Tracing dimension*.**

Definition of the time

The space and the time can be defined as follows:

> ***Space*** is the **area** where **energy** (object) is distributed.
>
> ***Time*** is a dimension to **trace** values in space dimensions.

We can express a Tracing dimension as an **imaginary component** of a spatial movement. A movement in k-dimensional space of $\boldsymbol{e}_1$ to $\boldsymbol{e}_k$ traced by $\boldsymbol{e}_0$ can be expressed as

$$d\boldsymbol{A}^k = idx^0 + dx^k \boldsymbol{e}_k$$

$$(= idx^0 + dx^1 \boldsymbol{e}_1 + dx^2 \boldsymbol{e}_2 + dx^3 \boldsymbol{e}_3 + \cdots\cdots + dx^k \boldsymbol{e}_k) \quad .$$

If $\boldsymbol{e}_1$ shows the Imaginary order of freedom when it is traced by $\boldsymbol{e}_0$, the corresponding movement in (k -1)-dimensional space of $\boldsymbol{e}_2$ to $\boldsymbol{e}_k$ traced by $\boldsymbol{e}_1$ can be expressed as

$$d\boldsymbol{A}^{k-1} = idx^1 + dx^m \boldsymbol{e}_m \quad (m = 2, 3, \text{- - -}, k).$$

2. 4D Spherical Model of the universe

Proposed model of the universe:

- ✓ Premise that there existed the initial energy showing vibrations in multiple dimensions.
- ✓ The space of the universe is the area where energy is distributed.
- ✓ The dimension showing the longest cycle in relative value change can work as a tracing dimension (***Original time*** or ***time***) to express value-changes of the other dimensions.
- ✓ ***Fundamental force*** works between energy pieces based on **momentums** (energy movements).
- ✓ The initial energy separated to two universes (***Giant separation***), which have opposite circulations in two planes in 4D space. The energy distribution **in 3D surface of a 4D sphere** turned to expand at the Big Bang (traced by the original time).
- ✓ Vibrations in the hidden dimensions render energy to the space.
- ✓ A vibration of the intrinsic energy (***Space energy***) vests additional energy (***Apparent energy***), which is our observable energy in 3D space as light or a quantum particle.
- ✓ The radius of the 4D sphere, which shows the imaginary order of freedom, can work as a common time for any locations in the space (***Observed Time*** or ***Time***).

Original tracing dimension (*time*) (longest wave period)

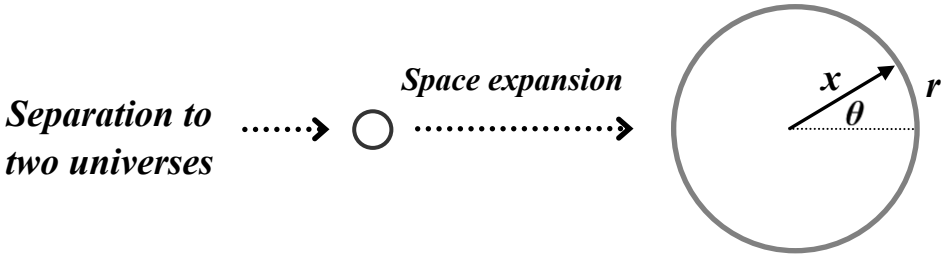
Four dimensions expanded → **4D sphere** ┬ **Radius** (imaginary order freedom) → ***Time***

└ **3D surface** → ***3D space***

Others (hidden dimensions) → **Compactified**

Vibrations quantized as energy → ***Space Energy***

4D Spherical Model



$\boldsymbol{x}$: Radius vector of 4D sphere

$\boldsymbol{x} = (x, \boldsymbol{\theta}) = (x, \theta_1, \theta_2, \theta_3)$ (4D spherical coordinate)

$\boldsymbol{r}$: 3D space vector corresponding to θ , $r = x\theta$

$\boldsymbol{r} = (r, \varphi_1, \varphi_2) = (x\theta, \varphi_1, \varphi_2)$

$\boldsymbol{x}$ by 4D cylindrical coordinate:

$\boldsymbol{x} = (x, r, \varphi_1, \varphi_2) = (x, x\theta, \varphi_1, \varphi_2)$

Movement in:

1) 4D space traced by t (Original time):

$$d\boldsymbol{A}(4)_t = iv_x dt + dx\boldsymbol{e}_x + dr\boldsymbol{e}_r$$

(The imaginary component is multiplied by v_x so that its metric for space expansion in $\boldsymbol{x}$ remains zero.)

2) 3D surface space traced by t:

$$d\boldsymbol{A}(3)_t = iv_x dt + dr\boldsymbol{e}_r \approx iv_{xc} dt + dr\boldsymbol{e}_r$$

$$v_r \equiv \frac{dr}{dt} \quad , \quad v_r = v_x V_r \approx v_{xc} V_r \quad \text{(expressed by } T\text{)}$$

$x\boldsymbol{e}_x$: radius vector of 4-D sphere

$r\boldsymbol{e}_r$: position vector in 3-D space

$v_x \equiv \frac{dx}{dt}$, v_{xc} : Current v_x (constant)

3) 3D surface space traced by T (Observed Time):

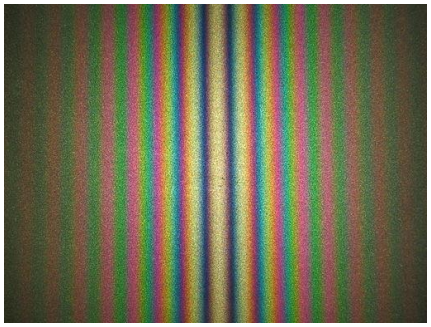
$$d\boldsymbol{A}(3)_T = idx + dr\boldsymbol{e}_r = idT + dr\boldsymbol{e}_r$$

$$V_r \equiv \frac{dr}{dT} = \frac{dr}{dx} \qquad V_x \equiv \frac{dx}{dT} = 1$$

3. Michelson-Morley experiment

Michelson-Morley (M-M) experiment

- did not detect ***shift*** of **interference fringe** by rotation or different time in day or year,
- is said to be a successful experiment that has proved the **absence** of the **light medium** (luminiferous aether).



Fringe pattern by white light (from Wikipedia)

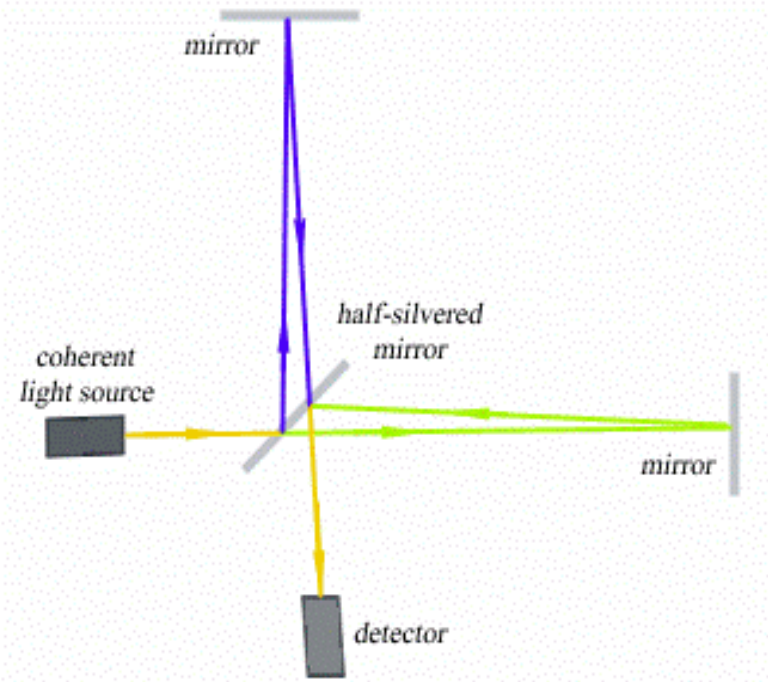
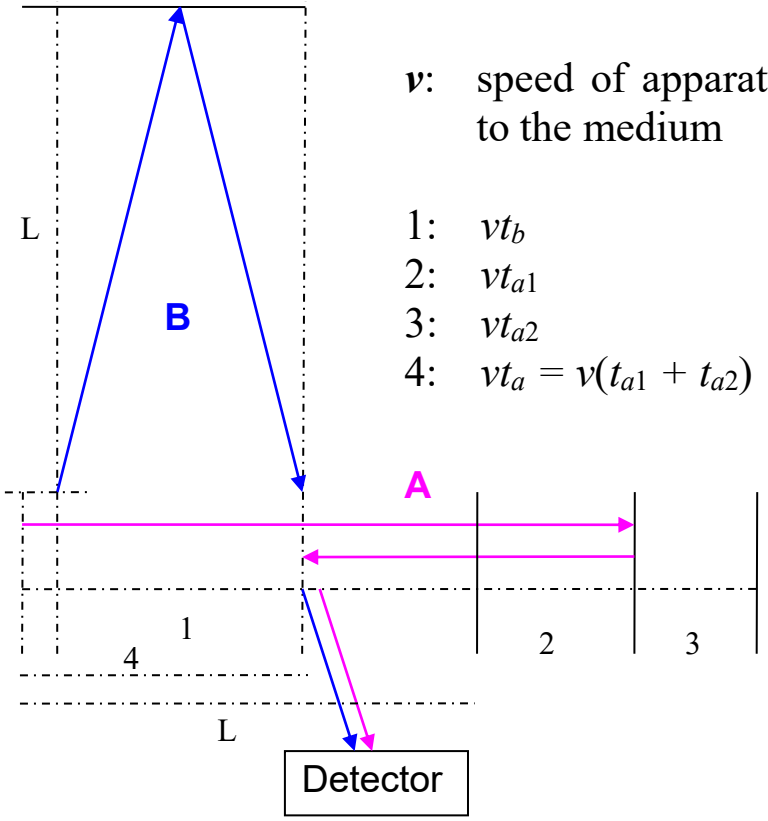


Figure S-10-2. Michelson-Morley experiment (from Wikipedia)

Is the **experimental design** indeed **capable** to detect the interference **fringe shift**?

M-M experiment by the frame stationary to the medium



v: speed of apparatus to the medium

1: vt_b
2: vt_{a1}
3: vt_{a2}
4: $vt_a = v(t_{a1} + t_{a2})$

- Phase propagation speed is constant independent of the speed of the emitter to the medium. The light speed is constant by the medium's frame.
- The route of **Beam A** parallel to the apparatus movement is longer than the route of **Beam B** for the round trip between the half-mirror and the end mirror.

$$D_a = L + \sqrt{L^2 + v^2 t_a^{\,2}}^{\,*} \quad , \quad D_b = \sqrt{4L^2 + v^2 t_b^{\,2}}$$

Because light speed is equal for both beams,

$$c = D_b / t_b = D_a / t_a \ . \qquad t_b^{\,2} = \frac{2L t_a^{\,2}}{L + \sqrt{L^2 + v^2 t_a^{\,2}}}$$

$$t_b < t_a \ \text{ if } \ v \neq 0 \ . \qquad \Delta t \equiv t_a - t_b$$

* From $D_a = L + vt_{a1} + L - vt_{a2} = 2L + 2vt_{a1} - vt_a$ and $t_a / t_{a1} = D_a / (L + vt_{a1})$, t_{a1} is eliminated.

Displacement of Beam A is released at the splitter Δt **earlier** than that of Beam B so that the two reach the same point at the same instance for interference detection.

M-M experiment by Medium's frame (continued)

Sum of amplitudes of Beam A and Beam B at the combined point:

$$U_a + U_b = A\sin\omega t + A\sin\omega(t+\Delta t)$$
$$= A\sin\left(\omega t + \frac{\omega\Delta t}{2} - \frac{\omega\Delta t}{2}\right) + A\sin\left(\omega t + \frac{\omega\Delta t}{2} + \frac{\omega\Delta t}{2}\right)$$
$$= 2A\cos\frac{\omega\Delta t}{2}\sin\left(\omega t + \frac{\omega\Delta t}{2}\right)$$

A : Maximum amplitude
ω : Angular frequency (of Beams A, B)

Propagation of the combined wave to the detector:

$$U_a + U_b = 2A\cos\frac{\omega\Delta t}{2}\sin\left(kx - \omega t - \frac{\omega\Delta t}{2}\right)$$

$$k = \omega/c$$

x Distance from the combined point in the direction to the interferometer
k : Angular wave number
c : Current light speed

By the **variation** of Δt there is **no change** of **frequency**, **wavelength** or **wave number**, while the **maximum amplitude** and the **phase** vary.

M-M experiment by the frame fixed to the apparatus

- Light travel distance: Same for both Beam A and Beam B ($2L$)
- Time: Same as time by the medium's frame
- Average light speed for round trip between half-mirror and end-mirror:

  Different between Beam A and Beam B shown by $c_A = 2L/(t+\Delta t)$, $c_B = 2L/t$

  Light speed by moving frame: $c_v = c - v\cos\theta$ (θ : angle between the light propagation and v)
- Direction of light propagation at the detector: Identical for Beam A and Beam B
- Therefore, light speed at the detector: Common for Beam A and Beam B

Combined wave propagation to the detector by apparatus' frame:

$$U_a' + U_b' = 2A\cos\frac{\omega\Delta t}{2}\sin\left(k'x' - \omega t - \frac{\omega\Delta t}{2}\right)$$

$$k' = \omega/c'$$

U_a', U_b', x', k' : measured by the apparatus' frame

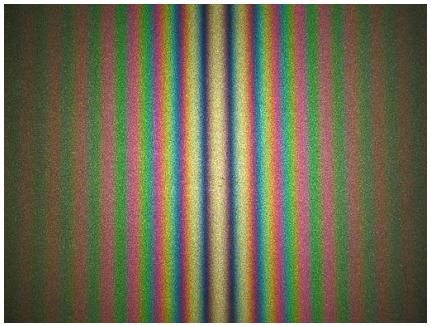
c' : Light speed by the apparatus' frame in the direction of x'

Conclusion by apparatus' frame is same as that by medium's frame:

No change of frequency, wavelength or wave number by variation of Δt

M-M experiment: Interference fringe

- The combined wave goes into interferometer, and passes through two slits with a very small distance.
- On the detection screen, interference fringe is shown.
- The location and pattern of the fringe depend on the slit pitch and the distance from the slits to screen.
- The fringe pattern varies by light frequency or wavelength, but is not altered by the variation of the phase of light.



Fringe pattern by white light (from Wikipedia)

Conclusion of Michelson-Morley type experiments:

By the **variation** of Δt , **no change** of **position** of interference fringe should be detected while the **brightness** of the fringe would be altered.

Reason why M-M like experiments are incapable to detect the interference fringe shift:

The two beams are finally combined in a ***common direction*** for measurement of interaction.

4. Acceleration factor

According to the 4D Spherical Model:

- Any energy in the 3D space is a vibration of the intrinsic space energy (Spacia) in the 4D space.
- There is a special frame stationary to the intrinsic space energy.
- The Principle of Relativity is no longer valid. Accordingly, the Theory of Relativity should be invalid. Energy-mass equivalence remains valid *.
- On the other hand, there should be limitations in movement of energy as wave propagation in medium.
- **Acceleration factor (f_a)** is newly introduced as a feature of wave in the equation of motion. Maximum speed is the phase propagation speed in the medium.

Special Relativity:

- **Propositions**; 1) Principle of Relativity, and 2) Principle of Invariant Light Speed
  The propositions were based on the results of the **Michelson-Morley experiment**, insisting the absence of medium for light. From the propositions, **Lorentz transformation** was induced.
- **Energy-mass equivalence**: * Can be induced from conservation of momentum of the total system including light without using the propositions or Lorentz transformation.

Mechanics of energy in 3D space

Measured in a frame stationary to the intrinsic space energy (Spacia)

Important features for our consideration:

- Any non-zero mass substance cannot accelerate to the light speed c.
- Not only the light speed cannot accelerate, but also it cannot decelerate.
- Light receives a gravitational force by a massive star to a direction perpendicular to its propagation, and bends to that direction (gravitational lensing).

To comply with them, reasonable to expect:

- Inertial movement of a stationary wave in its medium receives no resistance from the medium.
- Acceleration of a stationary wave: a factor depending on its speed to the medium would affect the acceleration. The maximum speed is the propagation speed of a phase in the medium.

Here propose "Acceleration factor (f_a)" for acceleration by force.

$$\alpha = \frac{F}{m} f_a \quad , \qquad F = \frac{m}{f_a} \alpha$$ *New equation of motion*

(The Acceleration factor is not applied for space expansion in 4-D sphere because it is not a wave propagation but movement of the intrinsic energy itself without medium.)

Acceleration factor (f_a)

From the fact light does not decelerate and the maximum speed is c:

$f_a = \left(1 - \frac{v^2}{c^2}\right)^n$ (n: positive real number) is expected.

In the section "4. Acceleration factor", "t" for "T" and "v" for "V_r" are used.

Working mass for force is the rest mass:

- Total energy is preserved. Rest mass is also conserved as the observation frame is fixed.

$$\Delta H = \Delta E_k + \Delta E_p + \Delta E_r = \Delta E_k + \Delta E_p + 0 = 0 \quad , \qquad \Delta E_k = -\Delta E_p$$

- Gravitational interaction of mass m with huge mass M from $r = \infty$, $v = v_0$ to $r = r$, $v = v$:
  In case of light:

$$-\Delta E_p = \frac{GM}{r} m \quad , \qquad \Delta E_k = 0 \ \text{(as } v = v_0 = c\text{)}, \qquad m_t c^2 = E_k \neq 0$$

Therefore, m cannot be the total energy mass m_t but should be the rest mass m_0 (= 0 for light).

Possibility of n for f_a and kinetic energy

If n = 1 :

$$f_a = 1 - \frac{v^2}{c^2} \quad , \qquad F = \frac{m_0}{f_a}\alpha = m_0\left(1 - \frac{v^2}{c^2}\right)^{-1}\alpha$$

$$E_k = \int F dr = \int m_0\left(1 - \frac{v^2}{c^2}\right)^{-1}\frac{dv}{dt}dr = -\frac{m_0 c^2}{2}\log\left(1 - \frac{v^2}{c^2}\right) + k \quad . \quad \text{At } v = 0,\ E_k = 0. \quad \therefore k = 0$$

$$E_k = -\frac{m_0 c^2}{2}\log\left(1 - \frac{v^2}{c^2}\right)$$ ***New formula for kinetic energy***

$$E_k = \frac{1}{2}m_0 v^2\left(1 + \frac{1}{2}\frac{v^2}{c^2} + \frac{1}{3}\frac{v^4}{c^4} + \frac{1}{4}\frac{v^6}{c^6} + \cdots\cdots\right)$$ (Taylor's expansion)

If n > 1 :

$$E_k = \frac{m_0 c^2}{2(1-n)}\left(1 - \left(1 - \frac{v^2}{c^2}\right)^{1-n}\right)$$

$n < 1$ **is denied** because $E_k \neq 0$ and $m_0 = 0$ for light.

Therefore, $n \geq 1$ is required.

Force in perpendicular direction to propagation

Light in parallel direction to propagation:

$$v_{(//)} = \pm c \ , \qquad m_0 = 0 \ , \qquad E_r = 0 \ , \qquad E_p = 0 \ , \qquad E_k = m_t c^2$$

Motion in perpendicular direction to propagation:

From the definition of perpendicular direction to propagation,

$$v_{(\perp)} = 0 \ , \qquad E_{k(\perp)} = 0$$

Because the total energy is conserved from selection of frame,

$$E_{r(\perp)} + E_{k(\perp)} = E_{r(\perp)} = E_{r(//)} + E_{k(//)} \ , \qquad \therefore \quad m_{0(\perp)} = m_t$$

In case of light:

$$v_{(\perp)} = 0 \ , \qquad m_{0(\perp)} = m_t \ , \qquad E_{r(\perp)} = m_t c^2 \ , \qquad E_{p(\perp)} = 0 \ , \qquad E_{k(\perp)} = 0$$

Rest mass for perpendicular direction is the total energy mass.
Light cannot be accelerated in propagation speed, but can be bent by force.

Acceleration factor: Conclusion

- There is a special frame stationary to the intrinsic space energy. The Theory of Relativity is no longer valid.
- As a feature of wave, an acceleration factor is newly proposed for the equation of motion. The maximum speed is the phase propagation in the wave medium.

Equation of motion: $\alpha = \frac{F}{m} f_a$

Acceleration factor: $f_a = \left(1 - \frac{v^2}{c^2}\right)^n \qquad (n \geq 1)$

- Kinetic energy is newly given as:

Kinetic energy:

$$E_k = -\frac{m_0 c^2}{2} \log\left(1 - \frac{v^2}{c^2}\right) \qquad (\text{if } n = 1)$$

$$E_k = \frac{m_0 c^2}{2(1-n)} \left(1 - \left(1 - \frac{v^2}{c^2}\right)^{1-n}\right) \qquad (\text{if } n > 1)$$

(Side note)

From the newly reported energy circulation theory, *n* for the acceleration factor is proved to be one. The equation of motion and the kinetic energy are given as follows.

$$F = \frac{m_0 \alpha_v}{1 - v^2/c^2} = M_0 \alpha_v = m_0 \alpha_0$$

$$E_k = -\frac{m_0 c^2}{2} \log\left(1 - \frac{v^2}{c^2}\right)$$

For details please refer to Kinetics of an Energy Circulation in the Space Energy.

5. Expansion of the universe

Come back to use t for the Original time and T for the Observed Time.

Space expansion in 4D sphere:

- Not a propagation of a wave but a movement of the space energy (Spacia) itself without a medium.
- The acceleration factor for wave propagation is not applied.
- There should not be a maximum limit of speed like the light speed c.
- The Newtonian equation of motion $F = m\alpha$ should be applied.
- According to the Energy Circulation Theory, the mass is defined as a quantity of the intrinsic energy shown by $E = mv_c^2$, (v_c: circulating velocity).
- A local angular area (with ΔE) by a 4D spherical coordinate system receives the **fundamental force** working on momentums with the whole circumference.

$$F = -K_f \frac{p_U \Delta p}{2\pi x^2} = -K_f \frac{E_U \Delta E}{2\pi v_c^2 x^2} = -K_f v_c^2 \frac{Mm}{2\pi x^2} = -K_f E_U \frac{m}{2\pi x^2}$$

$\Delta E = m\Delta p = mv_c^2$ (local area), $E_U = Mp_U = Mv_c^2$ (whole universe)

Process of expansion of the universe

Expansion speed (v_x) of the radius (x) of the universe by the Original time (t):

$$F = m\alpha\ ,\quad -K_f \frac{E_U \Delta E}{2\pi {v_c}^2 x^2} = \frac{\Delta E}{{v_c}^2}\alpha\ ,\quad \alpha = -K_f E_U \frac{1}{2\pi x^2}$$

Integrate the both sides by x from $x_0\,(v_x = v_0)$ to $x\,(v_x = v_x)$:

$$\int_{x_0}^{x} \frac{dv_x}{dt}\,dx = \int_{v_0}^{v_x} v_x\,dv_x = -\frac{K_f E_U}{2\pi}\int_{x_0}^{x} \frac{1}{x^2}\,dx$$

$$v_x{}^2 = \frac{K_f E_U}{\pi}\left(\frac{1}{x} - \frac{1}{x_0} + \frac{\pi {v_0}^2}{K_f E_U}\right) \equiv \frac{K_f E_U}{\pi}\left(\frac{1}{x} - K\right)$$

Use the unit for x as 1 at its maximum. $v_{x=1} = 0$, $K = 1$

$$v_x = \pm\sqrt{\frac{K_f E_U}{\pi}\left(\frac{1}{x} - 1\right)} \quad (\mu_0 \le x \le 1)$$

From $x = \mu_0$ to $x = 1$, the universe expands and then shrinks in accordance with this formula.

Speed of 3D space expansion:

$$v_r \equiv \frac{dr}{dt} = v_x\theta = \pm\theta\sqrt{\frac{K_f E_U}{\pi}\left(\frac{1}{x} - 1\right)} \quad \text{(by } t\text{)}, \qquad V_r \equiv \frac{dr}{dT} = \frac{dr}{dx} = \theta \quad \text{(by } T\text{)}$$

Continue to Part 2

< Part 2 >

6. **Light speed**
7. **Redshift**
8. **Light propagated distance**