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Hiroshi Michiwaki

Transition mechanisms of mass derived from the special theory of relativity and reducible set theoretical division by zero

1. Introduction

In the section titled "III. Discussion about the special theory of relativity and reducible set theoretical division by zero" in the note from October 10, 2014 titled "Research on the derivation of a parameter that connects physical equations and reducible set theoretical division by zero," we showed that when a finite mass (hereafter referred to as a massive particle) travels at the speed of light, the apparent relativistic mass m becomes 0, while on the other hand, the rest mass m_0 remains as a system. This was derived using reducible set theoretical division by zero described in the note from March 18, 2014.

In this note, we describe this interpretation in further detail. It is thought that A.Einstein believed that objects that travel at speeds greater than the speed of light c do not exist, except for light, based on his construction of the special theory of relativity and his interpretation of the Lorentz factor (refer to Equation (1)) in the Lorentz transformation. This is because he believed that at the limit $v \to c$, $\gamma \to \infty$, as shown in Equation (1):

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

It is believed that Einstein had no choice but to arrive at the interpretation that massive particles can never travel at the speed of light in order to avoid this illogical result. This is because the relativistic mass m is given by the following equation:

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (2)$$

According to reducible set theoretical division by zero, when $v = c$ in Equation (2), we obtain

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{1-\frac{c^2}{c^2}}} = \frac{m_0}{\sqrt{1-1}} = \frac{m_0}{0} = 0 \cdots m_0 \qquad (3)$$

Here, the symbol "..." on the rightmost side of Equation (3) means that everything after "..." is a remainder term.

2. The implications of Equation (3)

Equation (3) states that when an object travels at the speed of light *c*, the apparent relativistic mass *m* disappears and becomes 0, and that the rest mass m_0 appears as a system. In other words, this expression states that an object that is travelling at the speed of light c is observed as a rest mass m_0.

We apply this statement to Equation (3) using a photon as an example. Because the rest mass ${}^{c}m_0$ of a photon is

$$ {}^{c}m_0 = 0 \qquad (4) $$

we obtain

$$ {}^{c}m = \frac{{}^{c}m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{{}^{c}m_0}{\sqrt{1-\frac{c^2}{c^2}}} = \frac{{}^{c}m_0}{\sqrt{1-1}} = \frac{{}^{c}m_0}{0} = 0 \cdots {}^{c}m_0 = 0 \qquad (5) $$

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According to Equation (5), light (a photon) has no mass, regardless of whether it is at rest, traveling at the speed of light *c*, or traveling at a speed other than the speed of light *c*. In other words, its mass is invariably 0.

Next, consider a neutrino. Neutrinos are believed to have a finitely small rest mass ${}^{v}m_0$ (below several eV/c^2). Based on this, the mass can be expressed as :

$$ {}^{v}m(0) = {}^{v}m_0 > 0 \qquad (6) $$

Furthermore, for a speed of travel *v* that satisfies $0 < v < c$,

$$ {}^{v}m(v) = \frac{{}^{v}m_0}{\sqrt{1-\frac{v^2}{c^2}}} > {}^{v}m_0 > 0 \qquad (7) $$

holds. Furthermore, at the limit $v \to c$,

$$ \lim_{v \to c} {}^{v}m(v) = \lim_{v \to c} \frac{{}^{v}m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \infty \qquad (8) $$

In the local point $v = c$, we obtain

$$ {}^{v}m(c) = \frac{{}^{v}m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{{}^{v}m_0}{\sqrt{1-\frac{c^2}{c^2}}} = \frac{{}^{v}m_0}{\sqrt{1-1}} = \frac{{}^{v}m_0}{0} = 0 \cdots {}^{v}m_0 > 0 \qquad (9) $$

In other words, this implies that for a neutrino traveling at the speed of light c, the relativistic effect disappears, and as a result,

$$ {}^{\nu}m(c) = {}^{\nu}m_0 > 0 \qquad (10) $$

is observed.

It is thought that the above result is the mathematical mechanism in the special theory of relativity that follows from reducible set theoretical division by zero for mass changes for massive particles such as neutrinos.

This relationship is shown in the graph in Fig. 1. The light blue line in Fig. 1 corresponds to a graph of the Lorentz factor. As can be seen from this graph, the relativistic effect appears until $v \rightarrow c$, and when $c = v$, a strong discontinuity appears similar to division by zero, and ${}^{\nu}m(c) = {}^{\nu}m(0) = {}^{\nu}m_0$.

In other words, the most natural interpretation in reducible set theoretical division by zero is to conclude that for a massive particle traveling at the speed of light c, the relativistic effect disappears, and the original mass m_0 remains or appears.

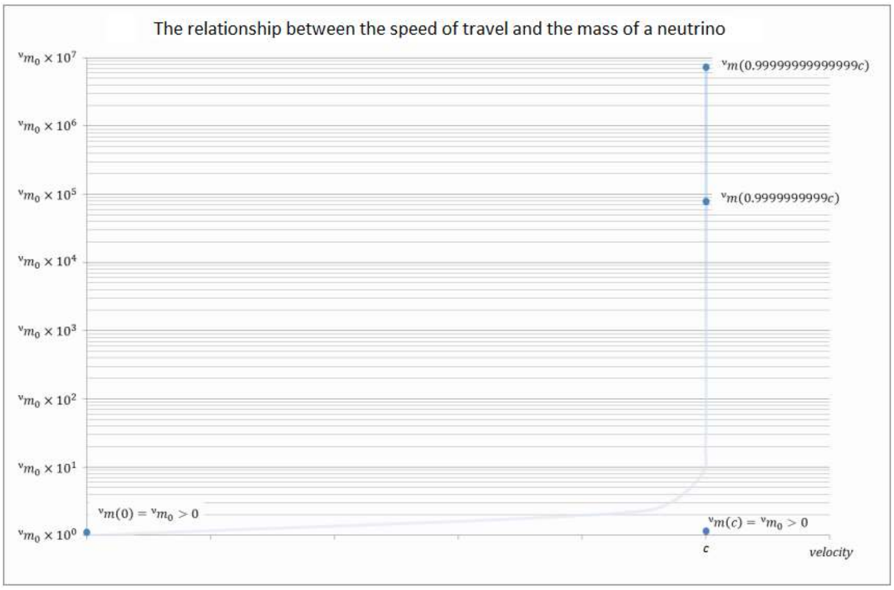

Fig. 1 The relationship between the speed of travel and the mass of a neutrino

If the speed is reduced from the speed of light c, then the apparent mass ${}^{\nu}m(v_2)$ will increase so that it satisfies ${}^{\nu}m(v_2) > {}^{\nu}m_0 > 0$. However, if the speed is reduced even further, then the apparent mass ${}^{\nu}m(v_1)$ will decrease so that it satisfies ${}^{\nu}m(v_2) > {}^{\nu}m(v_1) > {}^{\nu}m_0 > 0$ ($v_1 < v_2$) following the graph of the Lorentz factor.

It is important to capture the manner in which the speed decreases, and the mechanism of mass transition. It is possible that the mass transition is occurring with a discontinuous value. As a result, the infinite mass seen in Equation (8) does not appear in reality, and when the speed of the neutrino decreases from the speed of light c, it does not take on a value that is a limit value such as $v \rightarrow c$, and decreases through appropriate discrete values.

3. Note about the creation of Fig. 1

Optical observations and neutrino observations of the light that arrived at Earth on February 23, 1987 from the supernova explosion that was emitted from the Large Magellanic Cloud, which is 160,000 light-years away, as well as the observation results of the supernova explosion from M101, which is an astronomical phenomenon which was discovered on August 23, 2011 and which reached its peak on September 13, showed that neutrinos can escape supernova explosion regions more easily than light can, that neutrinos were observed preceding light in optical observations by 3 h, and that neutrinos and light that traveled to the Earth from 27,000,000 light-years away reached the Earth with almost no time difference. This observation shows that if it is assumed that there is a difference of only a few seconds in the time it takes for an object traveling at the speed of light and an object travelling at the speed of a neutrino to reach an observation point on the Earth from a supernova explosion, then an object travelling at the speed of a neutrino is able to travel at approximately 99.999999999999% of the speed of light. In this case, the value of the Lorentz factor in the Lorentz transformation becomes approximately 7.07×10^6, and the mass of a neutrino, which is less than several eV, will be observed as several MeV.

The following assumptions are made in the creation of Fig. 1.

i. A neutrino has a finite rest mass ${}^{\nu}m(0) = {}^{\nu}m_0 > 0$. If the rest mass is ${}^{\nu}m(0) = {}^{\nu}m_0 = 0$, then a neutrino will not exhibit any mass at any speed, similar to a photon. This would contradict the observed reality.

ii. The speed of light ratio of the neutrino travel speed was calculated from Table 2 based on assumptions about the difference in delay between the optical observations and the neutrino observations when the two supernova explosions (the Large Magellanic Cloud and M101-NGC5457) were observed, and based on the calculated value of the difference in delay in the neutrinos that traveled from the farther supernova explosion in particular. The difference in delay between the optical observations and the neutrino observations is assumed to be no more than several seconds, and the fact that the neutrinos, which are believed to be able to escape from the supernova explosion region more easily than light, arrived approximately 3 h earlier is ignored. Therefore, based on Table 2, a value of 99.999999999% is used for the speed of light ratio, which corresponds to a difference in delay of 8.46 s.

iii. The marker for ${}^{\nu}m(0.99999999999999c)$ on the graph uses the value of the Lorentz factor that corresponds to the speed of light ratio selected from Table 2 and applied to Table 3.

iv. The marker for ${}^{\nu}m(0.9999999999c)$ on the graph plots the value of the ratio of the published value for the upper limit of the mass of a muon neutrino to the published value for the upper limit of the mass of an electron neutrino corresponding to the value of the Lorentz factor in Table 3.

v. The marker for $v = c$ on the graph uses the result ${}^{\nu}m(c) = {}^{\nu}m(0) = {}^{\nu}m_0 > 0$ in Equation (9) and Equation (10).

Table 1: Relationship between neutrino speed v and number of seconds delay t in the Large Magellanic Cloud supernova explosion*

Speed of light ratio of neutrino travel speed	Required travel time [s]	Required number of years	Number of years of delay	Number of days of delay	Number of seconds of delay
90.000000000000%	5.61024000E+12	177,778	17,778	6,493,333	561,024,000,000.00
99.000000000000%	5.10021818E+12	161,616	1,616	590,303	51,002,181,818.18
99.900000000000%	5.05427027E+12	160,160	160	58,498	5,054,270,270.27
99.990000000000%	5.04972097E+12	160,016	16	5,845	504,972,097.21
99.999000000000%	5.04926649E+12	160,002	2	584	50,492,664.93
99.999900000000%	5.04922105E+12	160,000	0	58	5,049,221.05
99.999990000000%	5.04921650E+12	160,000	0	6	504,921.65
99.999999000000%	5.04921605E+12	160,000	0	1	50,492.16
99.999999900000%	5.04921601E+12	160,000	0	0	5,049.22
99.999999990000%	5.04921600E+12	160,000	0	0	504.92
99.999999999000%	5.04921600E+12	160,000	0	0	50.49
99.999999999900%	5.04921600E+12	160,000	0	0	5.05
99.999999999990%	5.04921600E+12	160,000	0	0	0.51
99.999999999999%	5.04921600E+12	160,000	0	0	0.05

*Distance to the Large Magellanic Cloud: 160,000 light-years, 1.51372×10^{21} m

Table 2: Relationship between neutrino speed v and number of seconds delay t in the M101 (NGC 5457) supernova explosion*

Speed of light ratio of neutrino travel speed	Required travel time [s]	Required number of years	Number of years of delay	Number of days of delay	Number of seconds of delay
90.000000000000%	9.46728000E+14	30,000,000	3,000,000	1,095,750,000	94,672,800,000,000.10
99.000000000000%	8.60661818E+14	27,272,727	272,727	99,613,636	8,606,618,181,818.09
99.900000000000%	8.52908108E+14	27,027,027	27,027	9,871,622	852,908,108,108.07
99.990000000000%	8.52140414E+14	27,002,700	2,700	986,274	85,214,041,404.30
99.999000000000%	8.52063721E+14	27,000,270	270	98,618	8,520,637,206.37
99.999900000000%	8.52056052E+14	27,000,027	27	9,862	852,056,052.08
99.999990000000%	8.52055285E+14	27,000,003	3	986	85,205,528.56
99.999999000000%	8.52055209E+14	27,000,000	0	99	8,520,552.10
99.999999900000%	8.52055201E+14	27,000,000	0	10	852,055.28
99.999999990000%	8.52055200E+14	27,000,000	0	1	85,205.55
99.999999999000%	8.52055200E+14	27,000,000	0	0	8,520.60
99.999999999900%	8.52055200E+14	27,000,000	0	0	852.08
99.999999999990%	8.52055200E+14	27,000,000	0	0	85.23
99.999999999999%	8.52055200E+14	27,000,000	0	0	8.46

*Distance to M101 (NGC 5457): 27,000,000 light-years, 2.5544×10^{23} m

Table 3: Relativistic mass magnification, calculated values of Lorentz factor

Speed of light ratio of neutrino travel speed	Speed of light squared (v^2/c^2)	1-(v^2/c^2)	√(1-(v^2/c^2))	1/√(1-(v^2/c^2))
90.000000000000%	0.81000000000000	0.19000000000000	0.435889894	2
99.000000000000%	0.98010000000000	0.01990000000000	0.141067360	7
99.900000000000%	0.99800100000000	0.00199900000000	0.044710178	22
99.990000000000%	0.99980001000000	0.00019999000000	0.014141782	71
99.999000000000%	0.99998000010000	0.00001999990000	0.004472125	224
99.999900000000%	0.99999800000100	0.00000199999900	0.001414213	707
99.999990000000%	0.99999980000001	0.00000019999999	0.000447214	2,236
99.999999000000%	0.99999998000000	0.00000002000000	0.000141421	7,071
99.999999900000%	0.99999999800000	0.00000000200000	0.000044721	22,361
99.999999990000%	0.99999999980000	0.00000000020000	0.000014142	70,711
99.999999999000%	0.99999999998000	0.00000000002000	0.000004472	223,607
99.999999999900%	0.99999999999800	0.00000000000200	0.000001414	707,115
99.999999999990%	0.99999999999980	0.00000000000020	0.000000447	2,235,720
99.999999999999%	0.99999999999998	0.00000000000002	0.000000141	7,073,895