Proposal of a New Experiment to Determine the Authenticity of Length Contraction: Cross-Collision

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In this study, I will propose a new experimental method to confirm whether length contraction or length expansion is correct. When proponents of length contraction prove or interpret it, they reverse the logic or change the observers. This is not the right way. However, in the case of the cross-collision experiment presented in this study, it is impossible to interpret it backwards or change the observers. Therefore, I think it is possible to determine whether the length contraction is correct or incorrect through this method.

I. Introduction

Since the theory of relativity was published, length contraction has also been recognized as correct, and few people have thought that there is a problem with this. However, despite the passage of time, no definitive experiment has been found that the length contraction is correct. You might think that measuring the length of a fast-moving object is difficult and impossible to confirm, but on the contrary, you may wonder whether the length contraction theory is true. Evidence is accumulating that the length contraction is not correct. In this study, I intend to propose an experiment that can determine the correct length, leaving all possibilities open.

II. Reasons to suspect length contraction

As the special theory of relativity was announced, length contraction was naturally accepted as a detailed theory of relativity. However, there are several reasons why we should suspect length contraction. We need not consider the Lorentz-Fitzgerald length contraction hypothesis here. Although the theory of length contraction was proposed by Fitzgerald and Lorentz, their work is not based on the theory of relativity and is merely a classical ether theory. Therefore, I will not consider their argument here. The length contraction of the theory of relativity was widely propagated mainly by the derivation of Weinstein and Hermann Bondi (*K calculus*) and the interpretation of Hoffman [1, 2, 3]. These three proofs or interpretations have something in common. As they derived formulas to prove length contraction or interpret experiments, they changed the observer's point of view according to their needs. This is very unfair and neither scientific nor logical.

1. Derivation of length contraction by Roy Weinstein

Weinstein derived the length contraction equation using the Lorentz transformation in 1960 [1]. However, there are serious errors in his derivation. In general, we assume that the observing subject is at rest and that the object being observed is in motion. According to the principle of relativity, this is natural. However, Weinstein claims that it moves, explaining $l_o \equiv x_2' - x_1'$ as the proper(rest) length. Two opposing assumptions are ambiguously included in an equation. He wrote $l_o \equiv x_2' - x_1'$, and applied the Lorentz transformation equation for this moving proper length. Is a '*proper length in motion*' possible? The proper length is the length that moves with the observer, can we apply the Lorentz transformation equation here? We should never accept this. This is an impossible concept from the beginning, and the length contraction equation derived from it cannot be accepted as a correct equation. Since Weinstein substituted the Lorentz transformation equation for a proper length, his derivation of length contraction is not valid. He drew that the proper length is fixed to S', and it is expressed that the S' system is in motion in Figure 1.

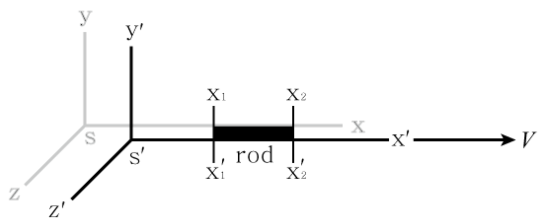


Fig. 1. Weinstein's moving proper(rest) length

$$l_o \equiv x_2' - x_1' = (x_2 - x_1)/(1 - v^2/c^2)^{\frac{1}{2}} \qquad (1)$$

$$x_1' = \frac{x_1 - vt}{(1 - v^2/c^2)^{\frac{1}{2}}}, \qquad x_2' = \frac{x_2 - vt}{(1 - v^2/c^2)^{\frac{1}{2}}} \qquad (2)$$

After substituting equation (2) into equation (1), he concluded that the expression obtained therefrom was a length contraction expression.

2. Derivation of length contraction by Herman Bondi

What Bondi wanted to derive is the length of the system in motion, so it is L in Figure 2 [2].

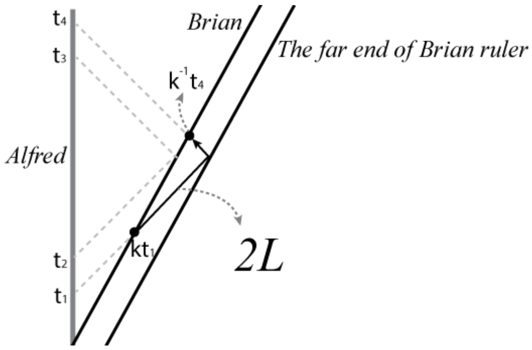


Fig. 2. Length L that Bondi intended to derive

He started from equation (3) and finally derived equation (4). He argued that this is a length contraction. Bondi wrote it as a monomial equation (4), not an identical equation, but let us rewrite equation (4) as an identical equation (5).

$$\frac{t_4}{k} - kt_1 = 2L \tag{3}$$

$$\vdots$$

$$L(1-\beta^2)^{1/2} \tag{4}$$

Since L is already on the right, L must not be on the left. Then, of course, L_O must be on the left.$(\beta = v/c)$

$$L_o = L(1-\beta^2)^{1/2} \tag{5}$$

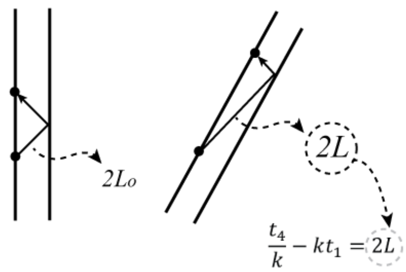


Fig. 3. The difference between the proper length and the observed length in the space-time diagram

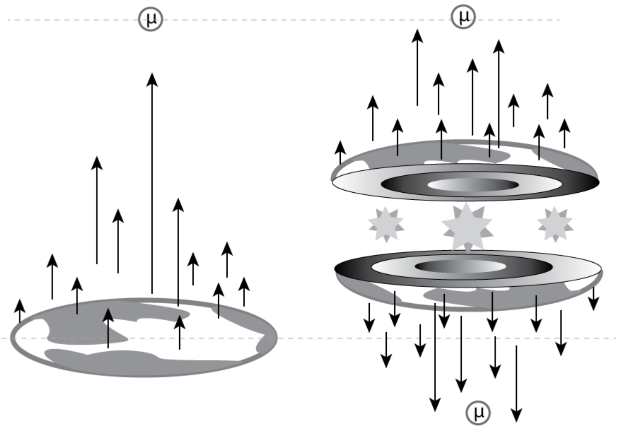
L_o is the proper length, and L is the length observed by the other party. Bondi tried to derive L from the beginning. Therefore, if Equation (4) is rearranged for L, it becomes as follows.

$$L = \frac{1}{(1-\beta)^{1/2}} L_o \tag{6}$$

In this case, it is not a length contraction equation, but rather a length expansion equation. Hermann Bondi described that length contraction was derived, but a logical analysis of his equation shows that length expansion is derived, not length contraction.

3. The phenomenon of a muon reaching sea level

It is correct to interpret the phenomenon of muon particles reaching sea level as evidence of time dilation [4], but it is incorrect to interpret this as evidence of length contraction. In his book '*Relativity, It's Root*', Hoffman interprets the Earth moving rapidly toward the muon when observed from the point of view of the muon [3]. This is an observer change. When he interprets this phenomenon as a time dilation, he interprets it from the perspective of an observer on the Earth, and he interprets it from the perspective of a muon when he interprets it as length contraction. Why does he change the observer's point of view in this way? He has no rational right and no reason to change the observer in this way.



(a) One muon and Earth (b) Two muons and Earth

Fig. 4. The contradictions that arise when we explain the muon reaching sea level by length contraction.
(a) Earth like a pancake
(b) Earth splitting into two sides and collapsing

The time dilation should be explained from the point of view of an observer on Earth, and the length contraction should also be explained from the point of view of the observer on Earth. This is because the subject who observed the phenomenon is not a muon but a human on Earth. To explain it from the point of view of the muon, it must be assumed that the Earth is shaped like a pancake. Furthermore, if two muons approach from both sides of the Earth, the Earth may be doomed to disintegrate. This is impossible. Therefore, observing the Earth from the point of view of a muon is logically unacceptable. The length contraction cannot be explained unless it is interpreted that the earth transforms into a pancake and flies toward the muon. As he tried to interpret the length contraction forcibly, I think he had no choice but to change the observer's point of view. The solution to this problem is simple. Accepting that the length expansion theory is correct and interpreting it from the point of view of an Earth observer solves all problems.

III. Reasons to consider length expansion as a relativistic correct length

1. Rejection of length contraction and opinions in support of length expansion

Recently, there has been a lot of discussion about the correct length for relativistic judgment. The problem of length contraction has been pointed out by many people. Strel'tsov pointed out the problem of length contraction by taking the concept of radar length [5], and Kwak insisted that the correct relativistic length is not length contraction, but the opposite length expansion [6, 7]. Buenker insisted that length expansion, not length contraction, was found in GPS [8]. And Sato argued that if the length contraction was correct, GPS would not work [9]. In addition, Ashby said that they found the effect of time dilation in GPS, and he passed over the effect of length contraction [10]. I think because he could not find any length contraction effect in GPS. Some argue for partial length expansion [11]. Given the opinions of these various authors, it is reasonable to suspect that there is a problem with the relativistic length as we know it.

2. Proof of length expansion from time dilation

We can simply prove the length expansion from the time dilation. (γ is Lorentz factor)

$$t = \gamma t_o \qquad \textit{time dilation} \tag{7}$$

$$ct = \gamma c t_o \qquad \textit{multiply both sides by } c \tag{8}$$

$$l = \gamma l_o \qquad \textit{length expansion} \tag{9}$$

3. Proof of length expansion from the constancy of the speed of light

If the principle of the constancy of the speed of light is correct, the speed must be constant in all inertial systems. Then, the following expression is given by

$$c = \frac{l}{t} = \frac{\gamma l_o}{\gamma t_o} = \frac{l_o}{t_o} = c \tag{10}$$

From Equation (10), it can be seen that $l = \gamma l_o$

4. Proof of length expansion from the transverse Doppler effect

Although there is no clear experimental evidence for length contraction, there is already a lot of experimental evidence for length expansion. One of them is the transverse Doppler effect. This is an observation of the frequency or wavelength of an object moving across in front of the observer. Suppose that an excited hydrogen atom passes in front of the observer at a relativistic speed. If so, the frequency of the hydrogen atom can be described as follows.[12]

$$\textit{Transverse Doppler Effect}: \ \nu = \nu_o\sqrt{1-\beta^2} \tag{11}$$

If the wavelength of the emitted light is shown as a picture, it is as follows.

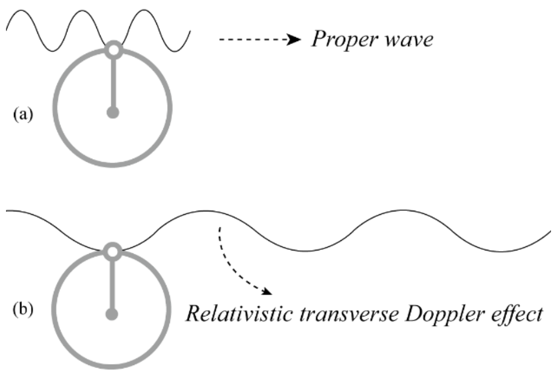


Fig. 5. Comparison of the classical Doppler effect and the relativistic transverse Doppler effect

Although the frequency of light emitted from fast-moving hydrogen has decreased, the speed of light emitted is constant, so, naturally, the relationship is $c = \nu\lambda = \nu_o\lambda_o$. Then, we can see that Equation (15) holds, and if this is converted to a general length rather than a wavelength, it can be written as Equation (16).

$$c = \lambda\nu \tag{12}$$

$$= \left(\lambda_o\frac{1}{\sqrt{1-\beta^2}}\right)\left(\nu_o\sqrt{1-\beta^2}\right) \tag{13}$$

$$= \lambda_o\nu_o = c \tag{14}$$

$$\therefore \ \lambda = \frac{1}{\sqrt{1-\beta^2}}\lambda_o \tag{15}$$

$$\therefore \ L = \frac{1}{\sqrt{1-\beta^2}}L_o \tag{16}$$

If we accept the transverse Doppler effect as relativistic experimental evidence, it is inevitably admitted that length expansion is also correct. The transverse Doppler effect is generally expressed as Equation (11). This is only the transverse Doppler effect expressed in terms of frequency and can be expressed in terms of wavelength, as shown in (15). If the transverse Doppler effect is not expressed as a frequency but as a wavelength, it can be confirmed that the length expansion is correct immediately (16).

IV. Cross-collision

We can see that length expansion is correct, not length contraction, from some experimental evidence that has already been revealed. Nevertheless, if you have any doubts about length expansion, I propose that you need a new experiment. It is impossible to interpret this experiment by changing the observer. In the phenomenon of a muon reaching sea level, which we looked at earlier, Hoffman explained the forced length contraction by setting up a pancake-like Earth. However, the experiment I am proposing does not allow for such an attempt.

When a spherical object moves rapidly, the shape of the object can be interpreted differently, as shown in Figure 6 according to each theory. If we interpret it as length contraction, the object will become very short, and if we interpret it as length expansion, the object will become very long.

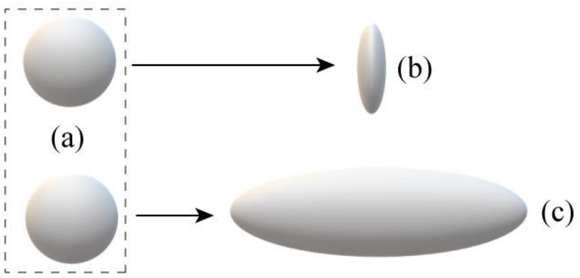


Fig. 6. (a) Non-relativistic particle
(b) Change in particle size due to length contraction
(c) Change in particle size due to length expansion

If the probability that a particle collides with a target particle (a) is P, then the area of (b) is reduced by $1/\gamma$, so the probability of collision with (b) will be $(1/\gamma)P$. In the case of (c), since the area is increased by γ, the collision probability will be γP. Then, if two paths through which these particles pass are installed vertically, the collision probability will change to $(1/\gamma)^2 P$ and $\gamma^2 P$.

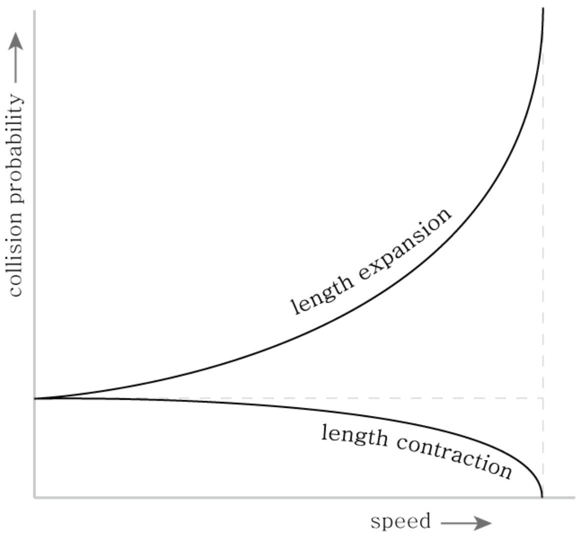


Fig. 7. Change of collision probability according to theory

In this case, we can determine whether the length contraction or the length expansion is correct by simply colliding the particles vertically. As the speed increases, the Lorentz factor increases, so the collision probability changes as shown in Figure 7.

Now, what we need to do is to install two particle accelerators vertically and then increase the speed of the particles to make them collide vertically. We only need to look at whether the collision frequency of the particles increases or decreases. The length expansion is correct if collisions occur more frequently than the classically expected value P, and the length contraction is correct if the collision frequency decreases more than P. This allows us to determine with certainty whether the length contraction is correct or whether the length expansion is correct.

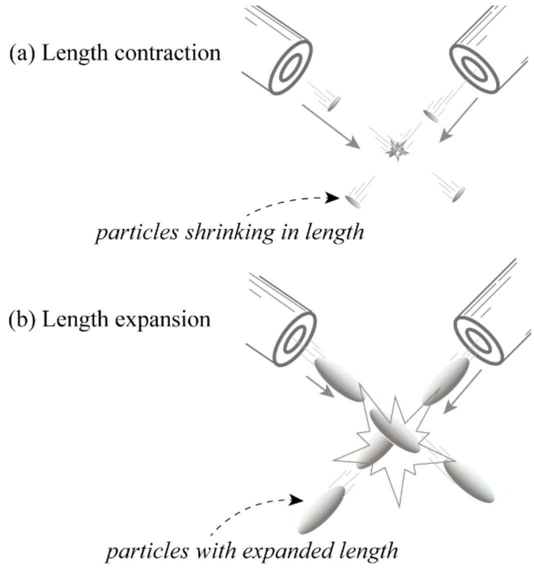


Fig. 8. Differences in the appearance of collisions according to theories

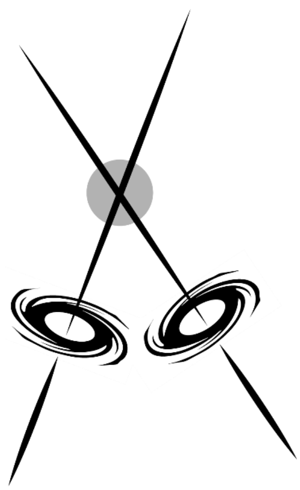


Fig. 9. Cross-collision due to collision of jets of black holes

If we are lucky, we may find a phenomenon like Cross-collision in space. Jets from black holes are ejected at near relativistic speeds. Therefore, if two black hole jets collide with each other, it has the same effect as the cross-collision above.

VI. Conclusions

In this paper, we have seen why we should suspect length contraction, and we have seen that length expansion may be right. If we run the cross-collision experiment presented in this paper and get the results, I think we will be able to judge for sure which theory is correct. If the length contraction phenomenon is denied and length expansion is confirmed, many questions, such as the paradox of invariance of the speed of light, Bell's spaceship paradox, Ehrenfest paradox, Muon paradox, will be solved simultaneously [6, 7, 13].

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