Proceedings of Institute of Mathematics of NAS of Ukraine 2004, Vol. 50, Part 2, 1006–1009

Symmetry in Relativistic Measurements

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The covarying scale effect in the observational relativistic measurement found a few years ago is that the Lorentz factor is a scale conversion ratio between the virtual covarying scale of measurement in relative motion and the real invariant scale at rest with respect to the observer. We find this scale conversion ratio being the bridge between two relative frames, and a logical symmetry for the measurement of the spatial distance and the measurement of time interval by using the same scale conversion. Hence the two relative frames are not only reciprocal to each other, but also symmetric with respect to the scale conversion to each other.

1 Introduction

A few years ago, we studied the space-time invariance in the Special Theory of Relativity [1]. To conserve the invariance, a scale conversion has been found necessary in between two inertial frames in relative uniform motion. The inseparable relationship between the relativistic measurement and the virtual covarying scale was discovered.

The scale is the size of the measuring unit. The scale used in any measurement is part of it. When extended to uniform relative motion, this concept calls for a measurement scale for the relativistic interval measurement. Such a scale can be called a “virtual covarying scale” which is part of the relativistic measurement. In other words, this is a principle of inseparability between relativistic measurement and virtual covarying scale.

This inseparability provides a sound logical foundation to reconfirm the Theory of Special Relativity, since any paradox simply can not happen when scale conversion exists.

The inseparability between the relativistic measurent and the virtual covarying scale serves as a bridge between two relative frames. Not only the relativistic measurements are reciprocal to each other between any two relative frames, but also symmetric to each other with respect to the scale conversion between the virtual covarying scale and the real invariant scale.

In the following sections we will show that the virtual covarying scale effect can explain the signal delay for the time interval measurement. With the same virtual covarying scale, one can explain why a linear accelerator needs not be built like a trombone physically for various energy levels, but functions like a virtual trombone.

2 The time interval measurement

To facilitate the time interval measurement in relative motion, let us use the reference frames as in the following Fig. 1.

Let us consider the two identical light clocks illustrated in Figs. 2 and 3 with photon emitters and detectors separated at a distance d from a mirror; c is the speed of light. One of the light clocks is stationary with respect to an observer and the other is moving at a uniform speed v relative to to the observer.

These gedanken Light Clocks have been used by Leighton [2] and others for certain demonstrations. We apply here to introduce a new concept of virtual covarying scale and the scale conversion as follows:

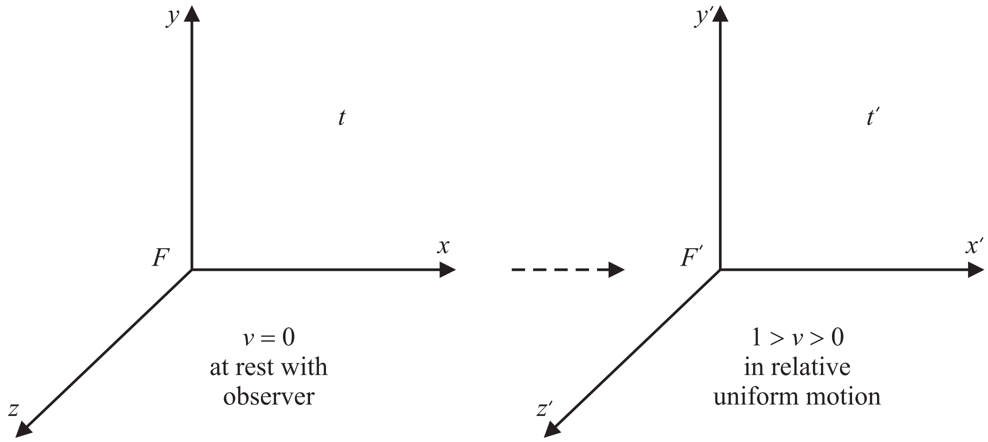

Figure 1. The inertial reference frames in relative uniform motion.

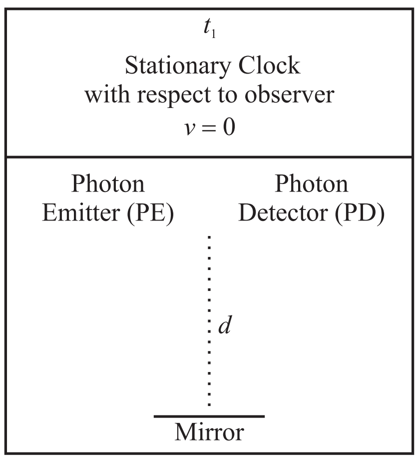

Figure 2. The cycle duration (t_1) of one period for a stationary clock.

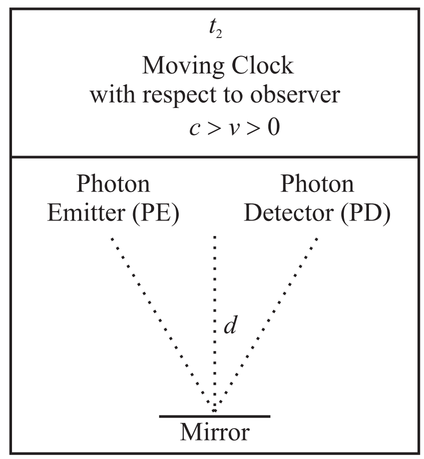

Figure 3. The cycle duration (t_2) of one period for a moving clock.

a) For the clock at rest with respect to the observer: For one period of proper time interval of resting clock cycle (the real invariant scale of the resting clock cycle),

$$t_1 = 2d/c. \tag{1}$$

b) For the uniformly moving clock with respect to the observer: For one period of improper time interval of moving clock cycle (the virtual covarying scale of the moving clock cycle),

$$t_2 = 2d/\left(c^2 - v^2\right)^{1/2}. \tag{2}$$

Thus the ratio between the virtual covarying and the real invariant scales is:

$$t_2/t_1 = \left[1 - (v/c)^2\right]^{-1/2}. \tag{3}$$

This ratio is exactly the Lorentz factor r, derived here in simple terms from comparison of scales of moving and stationary clock period. The Lorentz factor is thus the converter between the covarying and the invariant scales, the scale conversion ratio. The size of invariant real scale is amplified by Lorentz factor to become the virtual covarying scale which covaries with the relative speed automatically. Hence the relativistic time interval measurement is always inseparable from this virtual covarying scale [3], and is reciprocally symmetric to each other in between relative frames. Therefore, the well known "twin paradox" simply cannot happen because of the necessarily scale conversion.

It is worthwhile to notice that the real time duration is indeed independent of path as Sachs proved mathematically [4]. Lorentz factor is the scale converter, and is the equalizer for real time duration in all reference frames.

3 The spatial interval measurement

The relativistic spatial interval measurement is also inseparable from the virtual covarying scale [3] whose size is amplified by the Lorentz factor automatically. Any fixed linear accelerator for particles can accommodate those particle streams at various energy levels without being built like a trombone physically can demonstrate this automatic scale effect.

A Real Example can be found in the Stanford Linear Accelerator conducted experiments which began in 1966 with the completion of the 3-km-long linear accelerator (Linac), a machine capable of producing an electron beam with an energy up to 20 GeV initially. Experiments directed these electrons onto stationary targets to study the structure of matter. The maximum energy of the Linac was increased over the years to 50 GeV as part of an extensive upgrade required for its use in the Stanford Linear Collider (SLC). The 3-km-long accelerator continues to generate high intensity beams of electrons at the same fixed length.

These Linac experiments demonstrate clearly how a fixed length accelerator can be used to accelerate particle beams to different energy levels, and to accommodate different length contractions virtually without being built like a trombone. The logic behind these experiments was overlooked due to the traditional paradigm of misinterpretation and mismatched reference frame in thinking of material contraction [5, 6]. We now see that there is no material contraction but measurement change due to covarying scale change, and that inseparable relationship between relativistic measurement and covariant scale works naturally.

We now also understand that readings of the length measurement becomes smaller due to amplified covariant scale which covaries automatically with relative speed. The Lorentz factor is automatic conversion ratio between the covarying and the invariant scales.

Consider the kinetic energy K of the accelerated particle:

$$K = mc^2(r - 1), \tag{4}$$

where m is the rest mass of particle; c is the speed of light; r is the Lorentz factor.

We compute using equation (4), and list covariant length measurements at various kinetic energy (K.E.) level of particles along with the covarying scale size computed by using the Lorentz factor as scale conversion ratio in the 3 km long Linac:

Table 1. Measurements & scales

(A)	(B)	(C)	(D)
Kinetic energy (in GeV)	Covarying scale size (in real cm)	Covarying length (in virtual cm) (vir. cm) = (real cm) $\cdot$ r	Real length $(B) \cdot (C)$ (in real km)
50	97848.36	3.07	3
40	78278.89	3.83	3
30	58709.41	5.11	3
20	39139.94	7.66	3
10	19570.47	15.33	3

Why do we perform such numerous simple computations? Because we would like to illustrate the Principle of Inseparability between the relativistic interval measurement and the virtual covarying scale.

It also shows that the product of covarying scale size and the covarying length measurement always equals exactly to the same invariant length (3km) of Linac for each and every kinetic energy level of particle streams inside. If the traditional paradigm of interpretation with material contraction were correct, and with correctly matched reference frame and the necessary condition, then fixed length Linac would not have worked, but a trombone-like design for the tunnel would have been required to accommodate particle beams inside the accelerator at different relative speeds.

The fact that a fixed length on the solid ground works for a linear accelerator helps us see clearly that the virtual trombone works correctly without any material contraction. The accelerator accommodates relativistic lengths for accelerated particle beams at different speeds automatically. The covarying scale is amplified by the Lorentz factor, i.e.,

$$\text{Covarying scale} = \text{Invariant scale} \cdot \text{Lorentz factor}.$$

We are convinced that this logical interpretation is correct. Therefore, it warrants textbook correction of the traditional paradigm of interpretation in which the reference frame and the necessary condition of simultaneity were mismatched.

How lucky the mismatch might have been to provide the working design for Linac by lucky coincidence which is rare by doubling (i.e., the mismatched frame and the misinterpretation) to achieve a good working design and the construction of the accelerator. Thereby, unfortunately, the true logic became hidden. The conundrum of logical interpretation has been lingering.

We hope the understanding of the inseparability principle and correction of the traditional paradigm of interpretation will help resolve the conundrum of relativistic length measurement. The logical interpretation is now possible by the inseparable relationship between the relativistic measurement and the virtual covarying scale without any material contraction.

4 Conclusion

The symmetry with scale conversion for the virtual covarying scale and the real invariant scales between inertial frames in relative uniform motion provides the beauty of logical simplicity and a satisfactory interpretation of the relativistic measurement free from any paradox or any logical conundrum, and thereby readily reconfirms the theory.

More details and discussion on the subject of this paper are available at the following webpage `http://www.geocities.com/astronomer.geo/QNA.HTM`.

Acknowledgements

I am grateful for discussions with many friends, especially with Professor R.W. Nicholls of York University, Ontario, Canada.

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