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Comment on the paper by A.L. Kholmetskii "Remarks on the Correspondence of the Relativity and Causality Principles"

Vladimir Onoochin*

It is shown that attempts of Dr. Kholmetskii to find internal paradoxes in the relativistic theory, which is self-consistent one, are questionable.

Introduction

In a recent paper presented in this issue of the journal, Kholmetskii [1] claims about one paradox which seems to exist in frame of special/general relativity. This paper is in certain contrast with the majority view that the relativistic theory is an internally consistent theory which can only be falsified by experiment. However, the author states that the relativistic theory has some internal inconsistency. So this paper should attract some attention, but first of all, there appear some questions about correctness of the procedure of calculations developed by the author. To my point of view, this paper

* "Sirius", 3A Nikoloyamski lane, Moscow, 109004, Russia. E-Mail: a33am@dol.ru

is not free from some errors. Below I present my analysis of this work.

Because the author considers two different cases, i.e. the case of constant homogeneous gravitation field applied to the system, and the case of rigid non-inertial frame, let us analyse both these cases separately.

The case of constant homogeneous gravitation field applied to the one-dimensional chain of emitters

The author uses the following expression for the metrics of space-time (Ch 2.3 of Ref. 1):

$$ds^2 = c^2 dt^2 (1 + \frac{ax}{c^2})^2 - (dx)^2 - (dy)^2 - (dz)^2, \qquad (1)$$

However, the system considered by the author, *i.e.*, the system under applied constant homogeneous gravitational field, cannot be treated as the system with static field (the constant homogeneous gravitational field is always the certain approximation). In the metrics, given by the author, the space is no curved, *i.e.*, the spatial part of the metrics does not depend on the coordinates. However, if the magnitude of the gravitational potential is sufficiently large, one can expect that this magnitude exceeds the critical magnitude of the one-dimentional analogue of the Schwarzschild sphere and, therefore, the light pulse cannot leave the boundary of such a 1D 'sphere.' This simple example show us that using so simplified expression (the Eq. 1) for the metrics is questionable. I note that in the textbook [2], the authors use different equations for metrics in the problems of the particle(s) being in some static gravitational field (Eqs. 106.3 or 100.14)

$$ds^2 = (1 + \frac{2j}{c^2}) c^2 dt^2 - (1 - \frac{2j}{c^2})\left((dx)^2 + (dy)^2 + (dz)^2\right), \qquad (2)$$

$$ds^2 = (1-\frac{r_g}{r})c^2dt^2 - r^2\left(\sin^2\theta\, d\phi^2 + d\theta^2\right) - \frac{dr^2}{1-r_g/r}, \qquad (3)$$

I note that the Eq. 3 can be transformed to the Decartes coordinates (Problem 4 of Sec. 100 in [2]), and then be reduced to 1D case.

So the author uses the Eq. 1, which is the starting point of his calculations, without necessary substantiation.

The case of uniformly accelerating frame

It is difficult to understand from the content of the paper [1] which frames the observer and the chain of the emitters are being in. However, one can conclude from the following statement of the author

> *"Thus, an observer in an accelerated frame will detect the absolute event: the left and right light pulses will meet in the point defined by (23) (under negative sign of the acceleration a). This conclusion is in agreement with the result of sub-chapter 2.2 and the equivalence principle. However, here we meet a quite difficult problem: for observer in inertial frame both light pulses will never intersect."*

that the chain of the emitters is being at rest in inertial frame and the second observer, which detect '*meeting the light pulses*,' moves with constant acceleration along the x axis, *i.e.*, is rigidly linked with the uniformly accelerating frame.

The normal way of discussing an accelerating observer in special relativity is to attribute to this observer at any instant the coordinate system that would be used by an instantaneously comoving inertial observer [3]. However, we do not need to compare the times in two frames, but the events only. So we are not concerned of the problem that the second frame is non-inertial. Now let us consider what the second observer *sees*.

Obviously, this observer sees the chain of uniformly accelerating emitters moving in opposite direction. The note of the author "*(under negative sign of the acceleration a)*" can be treated as the observer and the light pulses move in opposite directions too. If the emitters are the point-like devices we are able to neglect the Lorentz contraction of each emitter as a whole. If the observer detects that, at initial instant, the distances between every pair of neighbour devices are equal to one value, saying, Δx, this observer will see that during the process of acceleration of the chain of the emitters, all distances between every pair of neighbour device remain to be equal to Δx. Let us find the time of passing the pulse of the distance Δx between the neighbour devices. Because in every frame the speed of light is constant and the observer sees that the emitters *are running away* from the light pulses, the velocities of the pulse and running away emitter *substrate*, so this time is:

$$T_{pass} = \frac{\Delta x}{c - v(t)}$$

where $v(t) = at \big/ \sqrt{1 + a^2 t^2 / c^2}$ is the velocity of the device at time t, and it is assumed that changing the velocity of the running away emitter is small during the process of propagation of the light pulse between two neighbour devices. Because this time depends on the current proper time of the second observer, the observer detects that the first and the second pulses pass the distance between two neighbour device for different time. One can easy find this difference

$$T2_{pass} - T1_{pass} \approx \Delta t \frac{d}{dt}\left[\frac{\Delta x}{c - v(t)}\right]$$

The observer sees that the time of processing the pulse in every device is increasing too as

$$T_{proc}(t) = T_{proc}(a=0)\cdot\left(1 + a^2t^2/c^2\right)$$

therefore, $T2_{proc}(t)$ always longer than $T1_{proc}(t)$ and as a result, the pulses never meet.

Estimate of possible experimental setup.

As one can see from analysis presented in [1], the physical reason of possible occuring *the event of meeting two pulses* is increasing the time of processing the light pulse inside the emitter caused by the relativistic effect. So to estimate the sizes of the experimental installation that would allow to check the statement of the author about existence of the paradox, we need to consider changing the time of processing for one separate emitter and then we multiply to the number of the devices.

For better resolution, we should work with the pulses which duration is as short as possible, taking into account that the sizes of each emitter cannot be large. To meet to two these requirements, we should use the emitters based on semiconductor microprocessors. The fastest microprocessors produced by IBM Corporation now have the operation time about 10 psec so the duration of the light pulse cannot be shorter 10 psec too. As a result, we must obtain the relativistic slowing of the time greater 10 psec. To avoid the errors that could be caused by spontaneous emission of the device, we should work with the time of processing no longer $10^6 \times 10$ psec $=$ 10 mcsec (the longer this time the better for the experiment). The relativistic slowing of the time is $dt = \frac{2ax}{c^2}T_{proc}$ for one emitter, and $dt = N\frac{2ax}{c^2}T_{proc}$ for the chain of the emitters. This value should be greater the duration of the light pulse, which corresponds to maximum of resolution, so

$$T_{pulse} = d\,t = N \frac{2ax}{c^2} T_{proc}$$

or

$$\frac{T_{proc}}{T_{pulse}} = 10^6 = \frac{c^2}{2axN} = \frac{9 \cdot 10^{16}}{2axN}$$

Because it is difficult to have the value of acceleration higher 10 m/sec under the laboratory conditions, finally we obtain that

$$xN \approx 10^9 \text{ meters}$$

So even we use one million of the emitters, each of size 1 mm, the length of the installation should be longer 2 kilometers. By the way, the deviation of position of each emitter from the *x* axis, i.e. in *y* or *z* directions, can be no greater 1 mcm (to meet the requirement that the resolution for the time interval between the light pulses is 10 psec; here, I omit simple geometric calculations to tolerances of the units of the installation). Actually, such an installation cannot be created on current technological level.

Conclusion

Because the analysis of the paper [1] shows that this work contains some essential errors, and the experimental verification of the effect being predicted by the author of Ref. 1 is impossible because on current technological level, the experimental installation cannot be made, the final statement of the author about existence of internal contradictory in the relativistic theory is questionable.

References

[1] A.L. Kholmetskii, "Remarks about correspondence of relativity and causality principles". *Apeiron*, this issue.

[2] L. Landau and E.M. Lifshitz, *Classical Field Theory,* New York, Pergamon Press, 1960.

[3] R.J. Low, When Moving Clocks Run Fast, *Eur. J. Phys*., v. 16, p.228, 1995.