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Response to Comment by A. Drory

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ABSTRACT

In a previous paper [2], we derived a generalized version of Einstein's clock synchronization rule for the case of inertial frames in which light speed is assumed to be anisotropic. The derivation was criticized in a recent comment by A. Drory [1]. We show that the criticism is not justified and, more importantly, that the postulate of relativity is necessary and **sufficient** in the derivation of the Lorentz transforms at the foundation of the theory of special relativity.

Keywords: *Anisotropic light speed, Einstein clock synchronization method*

1. RECAP: THE DERIVATION OF CLOCK SYNCHRONIZATION RULE FROM BASE PRINCIPLES

The Mansouri-Sexl [3] test theory of special relativity starts by admitting by reduction to absurd that there is a preferential frame Σ in which the light propagates isotropically with the speed c. All other frames in motion with respect to Σ are considered non-preferential and the light speed is anisotropic until proven otherwise.

In the current paragraph, we give the background of the original paper [2] criticized in Drorry's comment [1]. The setup described in figure 1 comprises a rod AB with a light source at the A end and a mirror at the B end. The rod of proper length $\rho_{AB}=\|\xi_A-\xi_B\|$ is at rest with respect to the preferential frame Σ.Non-preferential frame k and frame Σhave their axes aligned and there is a movement with constant velocity **v** along the x-axis. A light ray originating in A at time τ_A arrives at end B at time τ_B , gets reflected back to point A, where is arrives at time τ'_A

$$\tau_B - \tau_A = \tau'_A - \tau_B = \frac{\rho_{AB}}{c} \tag{1.1}$$

Frame k "sees" a different length $r_{AB}=\|x_A-x_B\|$, a different time t and a light speed that depends on direction: c'_+ in the positive direction of the x-axis and c'_- in the opposite direction. During the light trip from A to B the mirror at the B end of the rod recedes with speed v:

$$c'_+ t_+ = \| x_A - x_B \| + vt_+$$
$$t_B - t_A = t_+ = \frac{\| x_A - x_B \|}{c'_+ - v} \tag{1.2}$$

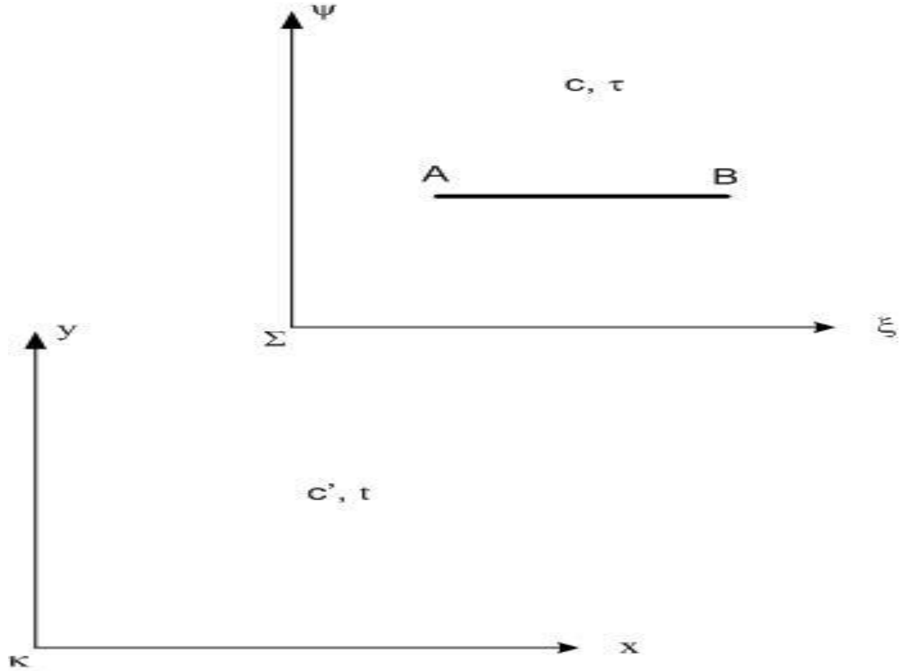

Fig 1:Einstein's setup

During the light trip from B to A the mirror in B recedes with speed –v:

$$c'_- t_- = \| x_B - x_A \| - vt_-$$
$$t'_A - t_B = t_- = \frac{\| x_B - x_A \|}{c'_- + v} \qquad (1.3)$$

Since $r_{AB} = r_{BA}$ it follows that $\| x_A - x_B \| = \| x_B - x_A \|$ therefore:

$$(t_B - t_A)(c'_+ - v) = (t'_A - t_B)(c'_- + v) \qquad (1.4)$$

Expression (1.4) represents the generalized Einstein synchronization condition **for anisotropic light speed**. Let $t=t(\xi,\tau)$be a continuous, two time differentiable function, then (1.4) can be rewritten as

$$(c'_- + v)[t(0,\tau+2\xi/c) - t(\xi,\tau+\xi/c)] = (c'_+ - v)[t(\xi,\tau+\xi/c) - t(0,\tau)] \qquad (1.5)$$

By using Taylor expansion we obtain:

$$(c'_+ + c'_-)\frac{\partial t}{\partial \zeta} + \frac{c'_+ - c'_- - 2v}{c}\frac{\partial t}{\partial \tau} = 0 \qquad (1.7)$$

Despite arguing about the approach in solving equation (1.7) Drory[1] agrees that the correct solution is:

$$t = b\left(\tau - \frac{c'_+ - c'_- - 2v}{c(c'_+ + c'_-)}\zeta\right) \qquad (1.10)$$

Running the same thought experiment in the reverse direction, that is, having light follow the path $B \to A \to B$, while the rod now moves in the negative x direction, we observe that (1.2),(1.3) become:

$$t'_B - t_A = \frac{\| x_B - x_A \|}{c'_+ + v} \qquad (1.2a)$$

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$$t_A - t_B = \frac{\| x_A - x_B \|}{c'_- - v} \qquad (1.3a)$$

where:

$$B(x_B, t_B) \to A(x_A, t_A) \to B(x_B, t'_B)$$
$$t_B = \tau$$
$$t_A = \tau + \xi / c$$
$$t'_B = \tau + 2\xi / c$$

Thus, (1.4) becomes:

$$(t'_B - t_A)(c'_+ + v) = (t_A - t_B)(c'_- - v) \qquad (1.4a)$$

resulting into (1.5) becoming:

$$(c'_+ + v)[t(0, \tau + 2\xi / c) - t(\xi, \tau + \xi / c)] = (c'_- - v)[t(\xi, \tau + \xi / c) - t(0, \tau)] \qquad (1.5a)$$

A simple comparison between (1.5a) and (1.5) shows that $c'_+ \leftrightarrow c'_-$, that is, (c'_+, c'_-) exchange roles in the definition of equation (1.5a) when compared to equation (1.5), resulting into (1.5a) having a different solution than (1.5), a solution that is obtained by exchanging the roles of (c'_+, c'_-) in (1.10) :

$$t = b\left(\tau - \frac{c'_- - c'_+ - 2v}{c(c'_+ + c'_-)}\zeta\right) \qquad (1.10a)$$

Comparing (1.10a) with (1.10) we arrive to the conclusion $c'_+ = c'_- = c'$ as demonstrated in the original paper[2]. In other words, we have assumed by reduction to absurd that there are inertial reference frames in which light speed is anisotropic and we have derived the opposite conclusion through a simple gedank experiment that bounces a light ray in opposite directions. The principle of light speed constancy is not necessary for the derivation of the Lorentz transforms, the principle of relativity is not only necessary but also sufficient for the derivation. Other authors have arrived, through different ways, to the same conclusion [4-8]. Light speed isotropy becomes a provable theorem, a consequence of the principle of relativity.

2. CONCLUSIONS

We have shown that Einstein's clock synchronization method implies light speed frame-invariance and that the principle of relativity is sufficient for the derivation of the Lorentz transforms.

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