

# On the Evolution of Approaches to the Space-Time Symmetry

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## ABSTRACT

The general space-time composition was analyzed starting in ancient times. During the previous three millenniums, to explain elementary physical phenomena, the world was twice admitted to be immersed into an “aether”. Presently the “aether” is assumed to be asymptotically close to the vacuum. This approximation is included in the foundation of the special theory of relativity.

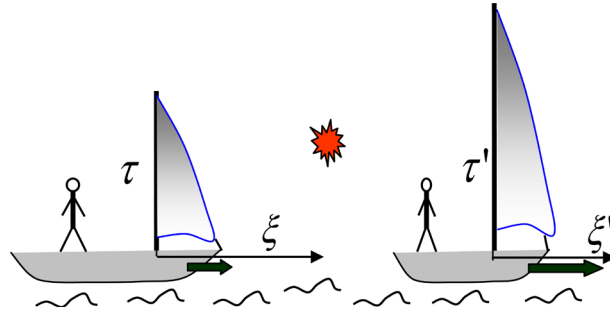
## 1. ANCIENT SPACE-TIME SYMMETRY

Primary opinions about the world harmony and symmetry were summarized by the Ecclesiastes (King Solomon, 990-931 BC) [1]: “Everything has its own time, and nothing is new under the Sun”. A half millennium later, Aristotle (384-322 BC) turned prone to the “horror vacuum” and speculated that the nature is immersed into an “aether” [2]. Another millennium later, Proclus (412-485 AD—the last head of the Athens Academy) dismissed Aristotle’s absolute reference frame for being not related to any physical phenomena [3].

## 2. GALILEO’S REFERENCE FRAMES

The ancient-Greek συμμετρειν (symmetrein = measure together) [3] was further developed by Galileo (1564-1642) [4, 5] who used to illustrate the equivalence of all inertial reference frames with floating boats (Figure 1), where the times  $\tau$ ,  $\tau'$  would be measured with beats of the man’s heart and the coordinates  $\xi$ ,  $\xi'$  would be measured with steps of the man’s foot (the two sailors being assumed identical).

By imposing a common time-coordinate unit (*conditionally equal to M beats of heart = N steps of foot = 1 buck*), the space-time homogeneity-isotropy [1, 3, 5] might be met, if the times  $\tau$ ,  $\tau'$  and coordinates  $\xi$ ,  $\xi'$  were interrelated with modernized [6-8] symmetric equations as



**Figure 1.** A Proclus-Galileo composition of inertial reference frames.

$$\begin{aligned} \xi &= \gamma\xi' + \kappa\tau' & \xi' &= \gamma\xi - \kappa\tau \\ \tau &= \kappa\xi' + \gamma\tau' & \tau' &= -\kappa\xi + \gamma\tau \end{aligned} \quad (1)$$

$\gamma$  and  $\kappa$  being constant coefficients. Inserting  $\xi = 0$  or  $\xi' = 0$  into Equation (1) gives the mutual velocities

$$\beta = \pm \kappa/\gamma \quad (2)$$

of the reference frames.

If the coefficients  $\gamma$  and  $\kappa$  were arbitrary, the formula (2) would admit an excessive freedom for motion of material bodies. But fortunately, according to Proclus [3], the Aristotle's "horror vacuum" is withstood by the space-time symmetry itself. Indeed, mutual substitutions between the columns (1) give identities under the condition \*)

$$\gamma^2 - \kappa^2 = 1, \quad (3)$$

and the combination of (2) and (3) gives the relation

$$\gamma = 1/\sqrt{1 - \beta^2} \quad (4)$$

imposing the absolute speed limit for the reference frames and thus for any material bodies

$$|\beta| \leq 1, \quad (5)$$

\*) Under the Minkowski change of variables [9], the left and right columns in (1) turn interrelated with rotation of relevant Descartes coordinates and, accordingly [8], the cyclic recurrence condition (3) turns equivalent to the theorem of Pythagoras. reproducing the 12<sup>th</sup> theorem of Proclus [3]: "Ἐν πεπερασμένῳ χρόνῳ τὸ ἀπείρῳ κινεῖσθαι οὐκ ἔστιν" = "During a limited time it is not possible to go an infinite distance" \*).

### 3. RECENT UP AND DOWN OF THE "AETHER"

However, in the second part of the 2<sup>nd</sup> millennium AD, the Ecclesiastes-Proclus-Galileo's concept of the space-time-symmetry [1, 3, 5] underwent a new irruption by the Aristotle's "aether": experiments and theories by Grimaldi, Newton, Huygens, Young and Fresnel revealed that the light is a wave [4]; Maxwell postulated it being electromagnetic [10]; and that wave (by analogy with the sound and the sea waves) seemed [11] to need a special medium to propagate in.

The electromagnetic "aether" was anticipated to move relative to the Earth with a velocity commensurable to the velocity of the Sun relative to the Earth. To detect the "wind" caused with the motion of the "Luminiferous Aether", Michelson and Morley used an interferometer [12] situated on a massive rotatable stone plate floating in a mercury bath; but, contrary to expectations, the measurements did not admit the "aether" velocity that would exceed one tenth of the Earth-to-Sun velocity. The light seemed to propagate in all directions with a practically common velocity ( $c = 3 \times 10^8$  m/s) [12]. The "paradox" was met by

Voigt [13] who, following the Ecclesiastes approach [1], provided every reference frame with its own time ( $t$  or  $t'$ ) and coordinate ( $x$  or  $x'$ ) scales and described the wave propagation with equations (cited in the introduction to the book [9] of Pauli):

$$\frac{\partial^2 \varphi}{\partial \xi^2} = \frac{\partial^2 \varphi}{\partial \tau^2} \Leftrightarrow \frac{\partial^2 \varphi}{\partial \xi'^2} = \frac{\partial^2 \varphi}{\partial \tau'^2} \quad (6)$$

$$\xi = x, \quad \tau = ct, \quad \xi' = x', \quad \tau' = ct'. \quad (7)$$

$\varphi$  being the wave field potential.

The Voigt's symmetric hyperbolic Equation (6) were cyclic-recurrent under the coordinate-time transformation (1) and (3) which, combined with (7) was identical with the Lorentz transformation [9]\*\*).

#### 4. CONCLUSIONS

The Aristotle's "aether" has been

- Converted by the special theory of relativity [9, 14] to a synonym of the vacuum—in agreement with the Ecclesiastes-Proclus-Galileo space-time symmetry [1, 3, 5].
- Replaced by the gravitation field in generalized relativistic theories [9].

\*) According to (1), if a body moves with a velocity  $\beta'_b$  relative to the  $\xi', \tau'$  frame, the body velocity relative to the  $\xi, \tau$  frame is

$$\beta_b = \frac{\beta'_b + \beta}{1 + \beta\beta'_b}$$

and if a body velocity is ultimate ( $\beta'_b = 1$ ) in one reference frame, it turns ultimate ( $\beta_b = 1$ ) in any other reference frame as well [8].

\*\*\*) Lorentz in a footnote at page 198 of his book "Theory of Electrons" [15] pointed out that the Voigt's coordinate-time transformation [13] was an earlier version of his (Lorentz) transformation, but that he did not know about it at that time.

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