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LETTER TO THE EDITOR

A suggestion to detect the anisotropic effect of the one-way velocity of light

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Abstract. We suggest an effect of the one-way velocity of light which can be detected by observing the angle of stellar aberration carefully.

One of the most debated problems in studying special relativity and the ether theory is whether the one-way velocity of light is really a constant or not (Erlichson 1973). In fact, the established facts have only verified that the average velocity of two-way light is constant, rather than the one-way velocity of light. This problem is actually connected with the convention of synchronising the distant clocks. Here we suggest an effect of the one-way velocity of light which can be detected by observing the angle of stellar aberration carefully.

As we know, owing to the orbital motion of the earth around the sun, one observes that the distant 'fixed' stars execute elliptical paths in the sky, the path being one year, and half the major axis of the ellipse being about 20·5″ of arc in each case. The value can be called the angle of aberration, and is defined by

$$tg\alpha = \bar{v}_{\text{earth}}/u_{\text{light}}. \tag{1}$$

According to special relativity, the one-way velocity of light, u_{light}, is a constant c in any inertial frame. Thus, equation (1) becomes

$$tg\alpha_{\text{E}} = \bar{v}_{\text{E}}/c, \tag{2}$$

where $\bar{v}_{\text{E}}$ is the average orbital velocity of the earth, by using Einstein's synchronisation. From equation (2), the angle of aberration is obviously a constant, independently of the direction of observation.

Nevertheless, we may adopt another convention of synchronisation, the absolute simultaneity, and take into consideration the generalised Galilean transformation (GGT), instead of the Lorentz transformation. Its two-dimensional form is

$$x' = \gamma(x - vt) \qquad \gamma = (1 - v^2/c^2)^{-1/2}$$
$$t' = \gamma^{-1}t \tag{3}$$

where x, t are respectively the space and time coordinates in the 'ether frame' Σ and x', t' are respectively the space and time coordinates in an inertial frame Σ'. v is the absolute velocity of Σ' with respect to Σ. Tangherlini (1958) and Mansouri and Sexl (1977) have studied this transformation and pointed out that with this transformation, the experimental results of special relativity may also be obtained. In addition, I have written a form of four-dimensional GGT (Chang 1979). In that case, the one-way velocity of light in Σ', such as the solar system, becomes

$$u_{\text{light}} = c/[1+(\boldsymbol{n}\,.\,\boldsymbol{v})/c] \tag{4}$$

where $\boldsymbol{n}$ is an unit vector in the direction of light and $\boldsymbol{v}$ is the absolute velocity of the solar system. Meanwhile, when using the absolute simultaneity, the orbital velocity of the earth $\bar{v}_{\text{earth}}$ is also definite. Substituting equation (4) into equation (1) leads to

$$tg\alpha_{\text{A}} = (\bar{v}_{\text{earth}}/c)(1+\boldsymbol{n}\,.\,\boldsymbol{v}/c). \tag{5}$$

This equation shows that the angle of aberration is not a constant, which should manifest a small anisotropic effect. If $v \simeq 300$ km s^{-1}, or $v/c \simeq 10^{-3}$, then the maximum deviation of the aberration angle from the average value is

$$(\Delta\alpha_{\text{A}})_{\max} = \bar{v}_{\text{earth}} v/c^2 \simeq 0{\cdot}02''. \tag{6}$$

It is interesting to see that this effect is somewhat like the anisotropic effect of the cosmic background radiation, whose magnitude is also just about 10^{-3} (Smoot 1977).

Unfortunately, the existing observation is not enough to distinguish between equations (2) and (5). In the following table, we give some values of the angle of aberration observed in past years.

Table 1. A list of the observed values of the angle of aberration.

Person	Period	The angle of aberration (seconds of arc)	References
Bradley	1728	20·25	(Laub 1909)
Struve	1844	20·445	
Späte r	1853	20·313	
Gill	1877	20·496	
Newcomb	1896	20·47	(Kulikov 1969)
Kulikov	1915–29	20·512	
Vashchilina	1840–2	20·486	
Romanskaya	1929–41	20·511	

Of course, the data in the list are quite incomplete. However, we can see from these data that the error of measurement is larger than the possible anisotropic effect given in equation (6). As pointed out by Kulikov (1969), the angle of aberration in the Newcomb system of astronomy, 20·47″, is most unreliable. On the other hand, the present value of the constant of stellar aberration given by IAU, 20·496″, is just a derived value, not the actual value of observation. Consequently, we think that it is possible to detect whether the one-way velocity of light is isotropic by systematically observing the angle of stellar aberration in different directions.

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