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The Quasi-Doppler Experiment According to Absolute Space-Time Theory

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We find the relation between the frequencies received by two observers placed at a given parallel with 180° difference in longitude when they observe a distant light (radio) source. This relation depends on the absolute velocity of the Earth; however, because of the occurrence of aberration, the effect cannot be registered in practice.

Poincaré[5] pointed out that the historic Bradley experiment, with whose help the aberration of light was discovered, can be used for the establishment of the Earth's absolute velocity, if the aether model of light propagation is the true one. We call such a modification of the Bradley experiment the quasi-Bradley experiment, and we show[4] that, according to our absolute space-time theory, the quasi-Bradley experiment must give a positive result.

The Bradley experiment consists of a change of the direction under which a distant light source (a star) is seen when the observer changes his velocity. However, when the observer changes his velocity the received frequency also changes. This represents the well-known Doppler effect. In the present paper we consider the problem of whether the observation of the Doppler shifts in the frequencies of distant stars during the diurnal rotation of the Earth can give information about the Earth's absolute velocity.

We call the *aberration in frequency* (in contrast to the *aberration in direction* discovered by Bradley) the change in the frequency of light coming from a distant light source when the observer changes his velocity. If we call

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the *Doppler experiment*[2] the determination of light velocity when observing the aberration in frequency, then the Doppler experiment performed with the aim of measuring the Earth's absolute velocity will be called the *quasi-Doppler experiment*.

The treatment of the quasi-Doppler experiment in the framework of our absolute space–time theory is very simple. Let us have (Fig. 1) a distant light source (a star) S and two observers O_1, O_2 who rotate with relative velocities $\mathbf{v}_{r1}$, $\mathbf{v}_{r2}$ ($v_{r1} = v_{r2} = v_r$) about some center C which moves with an absolute velocity $\mathbf{v}$. The absolute velocities of O_1 and O_2, which lie on the same line with the center of rotation, are

$$v_1^2 = v^2 + v_r^2 + 2vv_r \cos \varphi, \qquad v_2^2 = v^2 + v_r^2 - 2vv_r \cos \varphi \tag{1}$$

where φ is the angle between the velocity $\mathbf{v}$ and the velocity of the first observer $\mathbf{v}_{r1}$. Denote by δ the angle between the source–observer line and the velocity $\mathbf{v}$ at the moment of reception. Obviously δ is a constant angle, while φ changes by 2π during the period of rotation of O_1 and O_2. All angles are taken positive clockwise and negative counterclockwise.

According to our absolute space-time theory[3] if light with frequency ν is emitted by a source moving at velocity v, the frequency received by an observer moving at velocity v_0 will be

$$\nu_0 = \nu \frac{1 - (v_0/c) \cos \theta_0}{1 + (v/c) \cos \theta'} \left(\frac{1 - v^2/c^2}{1 - v_0^2/c^2} \right)^{1/2} \tag{2}$$

where θ_0 is the angle between the line connecting the emission position of the source with the reception position of the observer and the velocity of the observer at the reception moment, while θ' is the angle between the line connecting the reception position of the observer with the emission position of the source and the velocity of the source at the emission moment.

Writing in formula (2) first $\nu_0 = \nu_1$, $v_0 = v_1$, $\theta_0 = \theta_1$, and then

[2] The Doppler experiment was been performed seven years ago by Hoff.[1] Let us note that if Bradley had had a prism with resolution better than $\Delta\nu/\nu = 10^{-4}$, he could have discovered the *yearly aberration in frequency*, which is $\Delta\nu/\nu = 2v/c = 2 \times 10^{-4}$, where $v = 30$ km/sec is the velocity of the Earth around the Sun. The Doppler experiment is much easier than the Bradley experiment because only two photographs of the spectrum of light coming from a certain star are to be taken with a time difference of six months. Of course, Bradley did not have a camera, and even if a suitable prism had been at his disposal, he would have been unable to measure the shift in the frequencies.

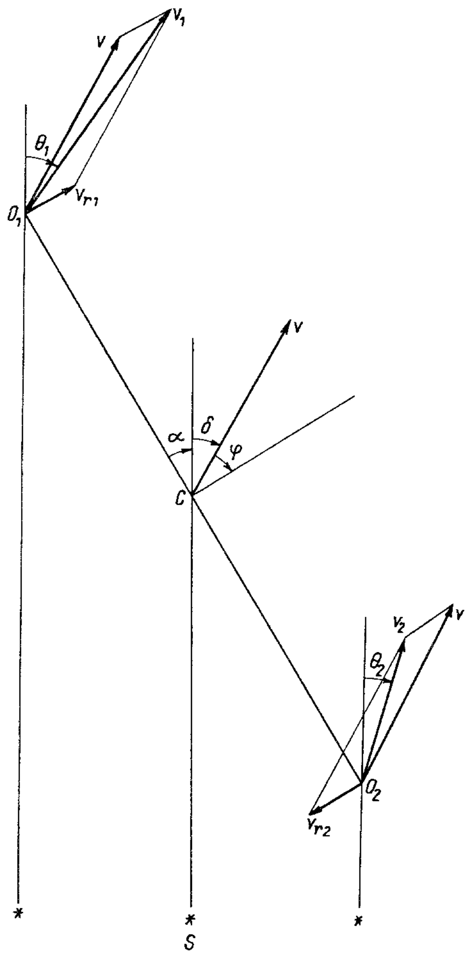

Fig. 1. The quasi-Doppler experiment.

$\nu_0 = \nu_2$, $v_0 = v_2$, $\theta_0 = \theta_2$ (see Fig. 1), and dividing the formulas obtained, we get

$$\frac{\nu_1}{\nu_2} = \frac{1 - (v_1/c)\cos\theta_1}{1 - (v_2/c)\cos\theta_2}\left(\frac{1 - v_2^2/c^2}{1 - v_1^2/c^2}\right)^{1/2} \tag{3}$$

Thus the relation between the frequency ν_1 received by the first observer and the frequency ν_2 received by the second observer does not depend on the velocity of the source.

From the figure we have

$$\begin{aligned} v_1 \cos\theta_1 &= v\cos\delta + v_r \cos(\delta + \varphi) \\ v_2 \cos\theta_2 &= v\cos\delta - v_r \cos(\delta + \varphi) \end{aligned} \tag{4}$$

Substituting (1) and (4) into (3), we find within an accuracy of second order in $1/c$

$$\frac{\nu_1}{\nu_2} = 1 - 2\frac{v_r}{c}\cos(\delta + \varphi) + 2\frac{vv_r}{c^2}[\cos\varphi - \cos\delta\cos(\delta + \varphi)] + 2\frac{v_r^2}{c^2}\cos^2(\delta + \varphi) \tag{5}$$

This final expression is convenient for discussion. Let us measure ν_1 and ν_2 received from a given light (radio) source for which $\delta + \varphi = \pi/2$. If $\delta = 0$, we will have $\nu_1 = \nu_2$ for $\varphi = \pi/2$; however, if $\delta = \pi/2$, we will have $\nu_1 = \nu_2(1 + 2vv_r/c^2)$ for $\varphi = 0$. This result leads to the conclusion that we can measure the Earth's absolute velocity in the following manner: Let us have two receivers placed at a parallel with 180° difference in longitude. Let us observe a radio source when it "crosses" the line O_1O_2 and let the frequencies received be sent to some middle point and there compared. Imagine for simplicity that this middle point is at the pole and that the Earth represents a flat disk. As we showed in Ref. 3 when considering the so-called "rotor–rotor" experiment, if light is sent from the rim of a rotating disk to its center, then the change in the frequency depends only on the rotational velocity, not on the velocity of the disk as a whole. Hence ν_1 and ν_2 when received at the pole will suffer equal changes, due to the daily rotation of the Earth. If now we compare ν_1 and ν_2 for any radio source which "crosses" the line O_1O_2, then for $\delta = 0$ the frequencies ν_1 and ν_2 will be equal precisely at the moment when the radio source is on the line O_1O_2, i.e., for $\delta + \varphi = \pi/2$; however, for $\delta = \pi/2$ the frequencies ν_1 and ν_2 will be equal when [see (5) and take into account that for the case considered $\cos(\delta + \varphi) \approx 0$]

$$\cos(\delta + \varphi) = v/c \tag{6}$$

Taking $v = 300$ km/sec,[2] we obtain

$$\cos(\delta + \varphi) = \sin\alpha \approx \alpha = 10^{-3} = 3', 4 \tag{7}$$

where α is the angle between the line O_2O_1 and the source–observer line. Such an angle is large enough to be reliably registered. However, the angle α is *exactly* equal to the aberration angle due to the motion of the Earth with velocity v. This signifies that when the line O_2O_1 makes an angle α with the source–observer line, the source *will be seen* along the direction O_1O_2. Thus, because of the occurrence of the aberration, the quasi-Doppler experiment leads in practice to a null result.

The problem solved in this paper was considered by Robertson,[6] who used the apparatus of special relativity, or rather, the technique of the Lorentz transformations. Robertson came to the conclusion that the relation between ν_1 and ν_2 depends only on the velocity of O_2 in the inertial frame where O_1 is at rest, or on the velocity of O_1 in the inertial frame where O_2 is at rest, i.e., only on the *relative* velocity of both observers: however (we should like to emphasize this), relative with respect to absolute space but not to the Earth, since with respect to the latter the relative velocity of both observers is equal to zero. In the case considered this relative velocity is equal to $2v_r$. We show with our formula (5) that the conclusion of Robertson is *not* true. The relation ν_1/ν_2 depends also on the absolute velocity v; however, the occurrence of the aberration in direction does not permit this dependence to be *experimentally* revealed.

Now we shall show that, for $v = 0$, our formula (5) [see also (3)] which reduces to

$$\frac{\nu_1}{\nu_2} = 1 - 2\frac{v_r}{c}\cos(\delta + \varphi) + 2\frac{v_r^2}{c^2}\cos^2(\delta + \varphi) = \frac{1 - (v_r/c)\cos(\delta + \varphi)}{1 + (v_r/c)\cos(\delta + \varphi)} \tag{8}$$

is identical with both formulas obtained by Robertson,[6]

$$\nu_1' = \nu_2' \frac{1 - (V/c)\cos\varphi_2'}{(1 - V^2/c^2)^{1/2}}, \qquad \nu_2' = \nu_1' \frac{1 - (V/c)\cos\varphi_1'}{(1 - V^2/c^2)^{1/2}} \tag{9}$$

where $V = 2v_r$ is the relative velocity of O_1 with respect to O_2 (and vice versa), φ_1' is the angle between the velocity of O_1 and the direction in which the source is seen if measured in a frame in which O_2 is at rest, and φ_2' is the angle between the velocity of O_2 and the direction in which the source is seen if measured in a frame in which O_1 is at rest. Our angle $\delta + \varphi$ is between the source–observer line and the velocity $\mathbf{v}_{r1}$. Thus this is the angle between the velocity of O_1 and the *opposite* direction in which the source is seen if measured in a frame in which the Earth were at rest, i.e., in absolute space.

It is obvious that, because of the aberration in direction due to the motion of O_1 and O_2, we have

$$\begin{aligned} \varphi_1' &= \pi - [\delta + \varphi + (v_r/c)\sin(\delta + \varphi)] \\ \varphi_2' &= \delta + \varphi - (v_r/c)\sin(\delta + \varphi) \end{aligned} \tag{10}$$

Putting (10) into (9) and taking into account that the aberration angle $(v_r/c)\sin(\delta + \varphi)$ is a small quantity, we obtain (8).

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