In Search of an Ether Drift

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Abstract

Special relativity theory (SRT) claims equivalence of all inertial frames, but it is generally acknowledged that there exists a dipole temperature distribution in the cosmic background radiation (CBR), which indicates that the solar system is moving through this unique inertial frame at a speed of approximately one percent of the speed of light. This evidence for a unique frame conflicts with SRT, and so motivates a search for additional evidence. Presumably, any ether drift should be directly detectable via experiment in either an earth-centered frame, or a sun-centered frame, or both. Spinning Mossbauer experiments, the Global Positioning System (GPS), and Very Long Baseline Interferometry (VLBI) are here analyzed for any evidence of ether drift; i.e., for evidence that the speed of light is not isotropic in all inertial frames. Though none of the experiments provides any direct evidence for ether drift, they do provide substantial indirect evidence.

Introduction

The Mossbauer effect can be used as both a source of and a detector of very precise gamma ray frequencies. This ability to provide and detect very precise frequencies stimulated their use in a number of attempts to directly detect an ether drift. These attempts are collectively referred to as "Spinning Mossbauer Experiments."They generally have both gamma ray source and detector on a spinning disk, with propagation across either the radius or diameter of the disk.

The spinning Mossbauer experiments are cited in a multitude of texts as providing strong evidence in support of SRT; namely, validating the claim of isotropic light speed in every inertial frame by showing that there is no detectable ether drift in the laboratory. If indeed it were possible to refute ether drift in such a simple fashion, it would be one of the simplest experimental contradictions to Poincare's principle that one could imagine.

But such claims are hollow. Howard Hayden [1] has argued that the spinning Mossbauer experiments are silent about the presence (or absence) of ether drift. He has shown the fallacy of such claims by showing that they are generally based upon two separate phenomena, a transit-time effect and a clock-speed effect. His agrument is largely similar to the development in the next section below.

Ruderfer [2] was among the first to suggest that the Mossbauer effect could be used to detect an ether drift. He reasoned that if an ether wind were present, it would affect the transit time of gamma rays crossing a spinning disk. The time derivative of the transit time as a function of path direction would appear as a frequency shift in the gamma ray. The frequency precision of the Mossbauer effect would allow measurement of this Doppler effect

Several groups implemented the experiment suggested by Ruderfer (e.g. Hay et al. [3] and Champeney et al. [4]). The ether-drift effect predicted by equation (4) was not detected.

By contrast, Turner and Hill [5] looked for a change in the frequency of gamma rays as a function of the source velocity. If an ether wind were present, presumably the frequency of the source would vary as the velocity of spin added and then subtracted from the ether wind velocity. The detector frequency would presumably vary in opposite fashion when placed on the opposite side of the spinning disk. In an erratum[6], Ruderfer, pointed out that the two effects (transit time and clock rate) on the source and detector would cancel and render all such experiment incapable of detecting an ether wind. Unfortunately, each of the experimenters ignored Ruderfer's erratum. In spite of the Ruderfer erratum, claims are repeatedly found in the literature that the spinning Mossbauer experiments support the special theory. They do not. They are simply silent as far as any direct evidence is concerned.

Analysis of the spinning Mossbauer experiments is a natural step toward analysis of the slightly more complex and much larger-scale Global Positioning System (GPS). This system constitutes a large scale near-equivalent to the spinning Mossbauer experiments. The transit time between the satellite and ground-based receivers is routinely measured. In addition, the atomic clocks on the satellite are carefully monitored; and high precision corrections are provided as part of the information transmitted from the satellites. Because the satellites and the receivers rotate at different rates (unlike the Mossbauer experiments), a correction for the motion of the receiver during the transit time is required. This correction is generally referred to as a Sagnac correction, since it adjusts for anisotropy of the speed of light as far as the receiver is concerned. Why is there no requirement for a Sagnac correction due to the earth's orbital motion? Like the transit time in the spinning Mossbauer experiments, any such effect would be completely canceled by the orbital-velocity effect on the satellite clocks.

There are two differences, which must be considered when dealing with GPS. First, instead of frequencies, GPS deals with the integrated frequency or difference in transit time. Second, the satellite source and receiver do not rotate at the same rate. But these differences are easily analyzed; and we find that, just as with spinning Mossbauer experiments, the GPS system provides us with no direct evidence about the presence or absence of ether drift.

Finally, analysis of the Global Positioning System and its ranging measurements is a natural precursor toward the analysis of the more complicated Very Long Baseline Interferometry (VLBI) range difference measurements. The VLBI experiments extend the phenomena of interest to aberration effects as well as the Sagnac effect

To prevent the equations from becoming too complex, a simplified VLBI system, with the VLBI receivers located at the same latitude, is analyzed in the VLBI Section below. All of the significant features of the more complicated general situation are exhibited by this simplified analysis. As with the prior systems, it is found that the VLBI experiments are moot as far as direct evidence is concerned for the existence or absence of any ether drift.

However, there are some significant lessons to be learned in the analysis process and some substantial indirect evidence for the presence of an ether drift. Thus, the CBR is not the only reason for believing that the speed of light is not isotropic on the surface of the earth.

The Spinning Mossbauer Experiments

Ruderfer gave the transit time across a spinning disk as:

$$\tau = \frac{\rho}{c - V_{frame} \, Cos\, \theta} \qquad (1)$$

where: τ is the transit time

ρ is the distance between source and detector

c is the speed of light

V_{frame} is the local frame velocity through the ether

θ is the direction of the transit path relative to the local frame velocity

Note that the ether-drift velocity through the isotropic-light-speed frame is the negative of the local-frame velocity. If the ether frame velocity is used rather than the local-frame velocity and the direction of θ changed to measure the transmission path relative to the ether-drift velocity, the sign of the equation is changed.

Equation (1) can be approximated to second order in the inverse speed of light as:

$$\tau = \frac{\rho}{c} + \frac{\rho}{c^2} V_{frame} \, Cos\, \theta \qquad (2)$$

The negative of the time derivative of equation (2) gives the apparent change in frequency of the source when it reaches the detector.

$$\left(\frac{\Delta f}{f}\right)_{drift} = \frac{\rho \, \dot{\theta} \, V_{frame} \, Sin\, \theta}{c^2} \qquad (3)$$

Equation (3) gives the difference in the expected frequency at the detector compared to the source. Three situations need to be considered. (1) The source located on the spinning edge and detector located at the center; (2) the source located at the center and the detector located on the spinning edge; and (3) source and detector located at the spinning edge on opposite sides. But the first two cases are simply the two halves of the third case. Thus, only the third case is considered; but the two halves are analyzed separately. For the third case we split the path into two parts so the distance of each half is the radial distance. In this case, $(\rho\dot{\theta})$ is simply the spin velocity of the edge. If we define θ′ as the direction of the spin velocity relative to the frame velocity, then (- *Cos*θ′) is equal to (*Sin*θ), and equation (3) becomes:

$$\left(\frac{\Delta f}{f}\right)_{drift} = -\frac{V_{spin} \, V_{frame} \, Cos\, \theta'}{c^2} \qquad (4)$$

Since the spin velocity is opposite on opposite sides of the disk, it must be noted that equation (4) applies specifically to the detector on the spinning edge, i.e. for the path from the center to the edge. The equation for the source on the spinning edge would have opposite sign for the same transit-path direction, i.e. for the path from the edge to the center.

Unfortunately, each of the experimenters ignored Ruderfer’s erratum [6] in which he stated that a counteracting clock-frequency effect would lead to a null result even in the presence of an ether drift.

Ironically, Turner and Hill [3] ran a similar spinning Mossbauer experiment and claimed a null result. However, they were looking for the clock-frequency effect and ignored the counteracting transit-time effect.

The clock-frequency effect is easily computed, assuming that the velocity through the ether affects the frequency by the amount Lorentz suggested and by the amount Einstein ascribed to the effect of the relative velocity of two observers.

Equation (5) approximated to second order gives:

$$\left(\frac{\Delta f}{f}\right)_{clock} = -\frac{1}{2}\frac{V_{frame}^2}{c^2} - \frac{V_{spin}\,V_{frame}\,Cos\,\theta'}{c^2} - \frac{1}{2}\frac{V_{spin}^2}{c^2} \qquad (6)$$

The first term of equation (6), due to the frame velocity, applies to both source and detector, whether they are at the edge or at the center and so always cancels. The third term, due only to the spin velocity, applies only at the edge and so cancels when both source and detector are at the edge. Otherwise it represents a real difference between source and detector frequency which must be specifically accounted for in the experimental design.

The middle term of equation (6), dependent upon both frame and spin velocity, is the term which counteracts the transit-time effect of equation (4). Consider the situation where both source and detector are on the edge of the spinning disk, and the position is such that the value of Cos θ’ is equal to one for the source and equal to minus one for the detector. Because the spin velocity and the frame velocity add at the source, the frequency of the emitted gamma rays will be lower. In this situation, the transit-time effect causes the apparent frequency to be increased. The amount of increase due to the first half of the path from edge to center will be precisely the amount to cancel the slower clock rate of the gamma ray source. Thus, the decreased source frequency cancels the first half of the increased transit-time effect. The second half of the increased transit-time effect causes the apparent frequency at the detector to be increased. But, because the spin velocity opposes the frame velocity at the detector, the detector is looking for an increased frequency. Indeed, the detector is sensitive to a frequency increased precisely by an amount equal to the increase arising from the second half of the transit time from the center of the disk to the edge. Thus, the change in source frequency due to spin, when the source is on the edge of the spinning disk, is counteracted by a transit-time effect of opposite sign as the gamma rays move from edge to center. But the change in detector frequency due to spin, when the detector is on the edge of the spinning disk, is counteracted by a transit-time effect of the same sign as the gamma rays move from the center to the edge.

In conclusion, the spinning Mossbauer experiments do not indicate the absence of any ether drift. They simply indicate that, if an ether drift is present, clocks are slowed as a function of their velocity through the ether. Thus, the results of the Mossbauer experiments are in complete accord with the Lorentz ether theory and with Poincare’s principle. They do not contradict the special theory of relativity, but they certainly do not support it to the exclusion of an ether theory.

GPS One-Way Range Measurements

The effect of an ether drift on the GPS one-way range measurements is exactly counteracted by the effect of the ether drift on the receiver clocks. This result is quite similar to the cancellation effects which occur in the Mossbauer spin experiments and implies that GPS range measurements provide no information regarding the isotropy of the speed of light

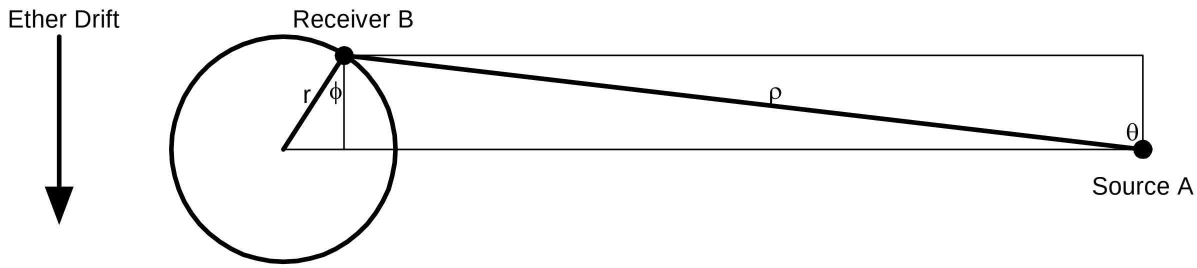

Figure 1 Ether Drift Geometry for GPS

Let us illustrate the canceling effect with some simple geometry. Let a source signal be generated by object A (see Figure 1), which, for the moment, is treated as a GPS satellite. Let the receiver, object B, lie on the earth's surface. Now let the path between A and B (designated by ρ) and the ether-drift velocity through the receiver (object B) define a plane. Assume the ether drift is caused by the earth's orbital motion. The plane defined above will intersect the earth in a small circle. Let the vector r be defined by the earth-radius vector of B projected onto the plane defined above. When measurements are made, assuming a non-rotating earth-centered frame and no ether drift, the transit time, τ, is given by:

$$\tau = \frac{\rho}{c} \qquad (7)$$

where: ρ is the range from the source at time of transmission to the receiver at time of reception
c is the speed of light

The computed range is then:

$$R_{ab} = c\tau = \rho \qquad (8)$$

Now, when an ether drift is allowed as in Figure 1, the transit time will become:

$$\tau_{ab} = \frac{\rho}{c - v_o \ Cos\theta} \approx \tau + \frac{\rho v_o \ Cos\theta}{c^2} \qquad (9)$$

where: v_o is the velocity of movement through the ether (minus ether-drift velocity)
θ is the angle which the ray makes with respect to movement through the ether

But ρ Cos θ is simply the component of ρ in the up-wind direction. Thus:

$$\tau_{ab} \approx \tau + \frac{\rho \cdot v_o}{c^2} \tag{10}$$

The last term in equation (10) indicates that the range will be measured as a larger value in the presence of an ether drift—unless there is some offsetting factor. But the change in clock rates in an ether-drift field contribute just such an offsetting factor.

The effect on time, which the special theory claims is caused by relative velocity, is ascribed by most anti-relativists to an effect on clocks caused by the velocity of the clock relative to the isotropic light-speed frame. Now, if we make this assumption, the clock rate for any clock moving with respect to the earth's center (assuming a sun-centered frame and an ether drift from the orbital velocity) is:

$$f' = f\sqrt{1 - \frac{(v_o + v_s)^2}{c^2}} \tag{11}$$

where: v_o is the earth's orbital velocity
v_s is the velocity with respect to the earth's center

Thus:

$$\frac{\Delta f}{f} \approx -\frac{(v_o + v_s)^2}{2c^2} \tag{12}$$

Expanding:

$$\frac{\Delta f}{f} \approx -\frac{v_o^2}{2c^2} - \frac{v_s^2}{2c^2} - \frac{v_o \cdot v_s}{c^2} \tag{13}$$

The first term is a simple constant clock-rate term that affects all of the clocks equally since they all are moving with the earth's orbital speed. Thus, it can be ascribed to clock design and the rate adjusted appropriately. The second term can also be ascribed to clock design if the moving clock is always moving at a constant speed (such as clocks at a fixed location on the earth and clocks in circular orbit around the earth). If a clock is moved at a variable speed and is used to synchronize other clocks via slow transport, the second term can be made arbitrarily small. But the last term does contribute to a clock bias term as a function of the clock position. The clock bias is given by the integral of the last term in equation (13). If the orbital velocity is assigned the direction of the X axis, then the component of v_s in the direction of the orbital velocity is given by dx/dt and the clock-bias term is given by:

$$\Delta clock = -\frac{v_o}{c^2}\int \frac{dx}{dt}dt = -\frac{v_o\, x}{c^2} \tag{14}$$

This means that the clock bias due to the ether drift at the receiver will be:

$$\Delta clock(B) = -\frac{r \cdot v_o}{c^2} \tag{15}$$

and the clock bias at the source:

$$\Delta clock(A) = -\frac{r \cdot v_o}{c^2} + \frac{\rho \cdot v_o}{c^2} \tag{16}$$

These clock biases will affect the measured transit time of the signal. To get the new transit time, the transit time in equation (10) must be modified by adding the clock bias at the receiver (B) and subtracting the clock bias at the source (A). This gives:

$$\tau_{ab} \approx \tau + \frac{\rho \cdot v_o}{c^2} - \frac{\rho \cdot v_o}{c^2} \approx \tau \qquad (17)$$

Is it proper to conclude that there is no way to tell whether the local gravitational region determines the speed of light? For GPS satellites in orbit around the earth, the answer is yes. One-way range measurements cannot directly determine the absence or presence of ether drift. However, indirectly, the counteracting effects of the transit time and clock slowing induced biases indicate that an ether drift is present. This is because there is independent evidence that clocks are slowed as a result of their speed. Thus, ether drift must exist or else the clock slowing effect would be observed.

VLBI and One-Way Speed-of-Light Range Differences

The first step in extending the GPS analysis in the above section to the VLBI situation is to add a second receiver and consider only the time difference in the two transit times. The use of a nearby source will help to clarify the phenomena involved. If the geometry is simplified a bit by assuming the second receiver is in the same plane defined above, it is easy to see from equation (10) that the measured time difference in the presence of an ether drift (motion through an isotropic light-speed frame) is just:

$$\tau = \frac{\rho_1}{c} - \frac{\rho_2}{c} + \frac{\rho_1 \cdot v}{c^2} - \frac{\rho_2 \cdot v}{c^2} = \frac{\Delta\rho}{c} + \frac{b \cdot v}{c^2} \qquad (18)$$

where: ρ_1 is the range to the up-wind receiver
ρ_2 is the range to the down-wind receiver
b is the baseline vector between the two receivers
v is the velocity through the isotropic frame
$\Delta\rho$ is the difference in the two ranges

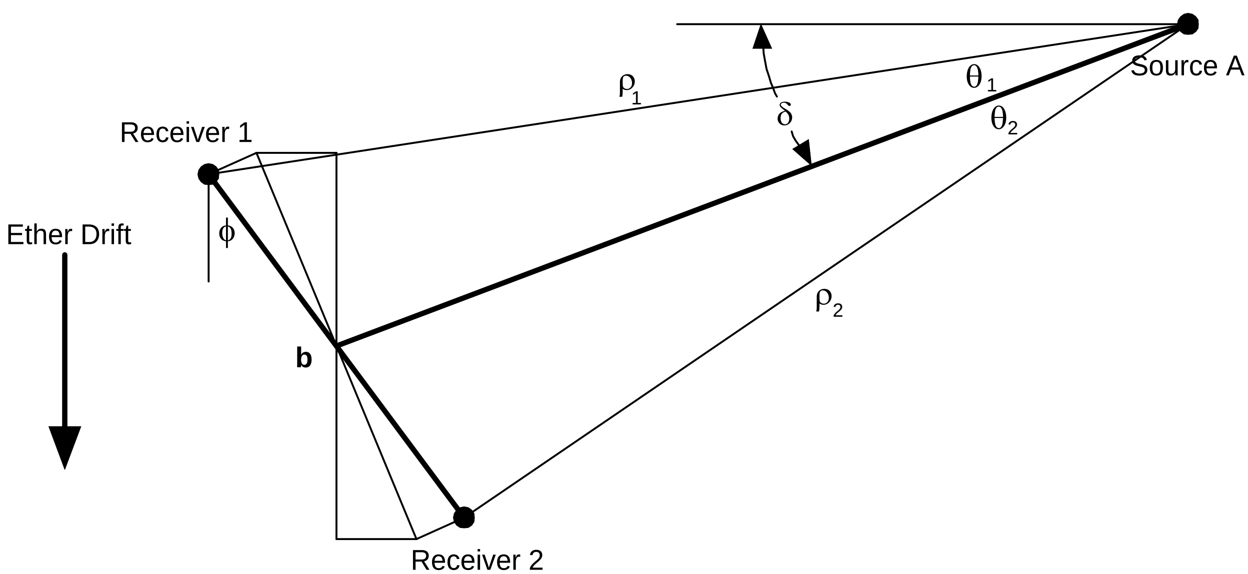

Figure 2 VLBI Geometry with Nearby Source

But it is also clear from equation (15) that the clock biases induced by their motion through the isotropic frame will contribute an effect which will cancel the last term. Thus:

$$\tau = \frac{\Delta\rho}{c} + \frac{b \cdot v}{c^2} - \frac{b \cdot v}{c^2} \tag{19}$$

Any effect of the source clock is canceled in the range-differencing process. The last term in equation (18) is composed of two physical effects. This becomes more obvious if equation (18) is derived in another fashion.

Using the angles defined in Figure 2, the transit time from the source to receiver 1 is:

$$\tau_1 \approx \frac{\rho_1}{c} - \frac{\rho_1}{c}\frac{v}{c} Sin\left(\delta - \theta_1\right) \tag{20}$$

In like manner the transit time to the second receiver is:

$$\tau_2 \approx \frac{\rho_2}{c} - \frac{\rho_2}{c}\frac{v}{c} Sin\left(\delta + \theta_2\right) \tag{21}$$

Expanding the sine of the sum of two angles in each case and taking the difference of these two equations gives:

$$\tau = \frac{\Delta\rho}{c} - \frac{\left(\rho_1\ Cos\ \theta_1 - \rho_2\ Cos\ \theta_2\right)}{c}\frac{v}{c} Sin\ \delta + \frac{\left(\rho_1\ Sin\ \theta_1 + \rho_2\ Sin\ \theta_2\right)}{c}\frac{v}{c} Cos\ \delta \tag{22}$$

Since the angle, δ, defines the path from the source to the midpoint of the baseline in Figure 2, it is possible to make a geometric substitution into equation (22) to get:

$$\tau = \frac{\Delta\rho}{c} - \frac{b}{c} Sin\left(\varphi - \delta\right)\frac{v}{c} Sin\ \delta + \frac{b}{c} Cos\left(\varphi - \delta\right)\frac{v}{c} Cos\ \delta \tag{23}$$

The second and third terms of equation (23) can be interpreted as separate physical effects. The second term is just the decrease in the differential transit time which arises due to the receiver motion after a wave-front reaches one receiver and before it reaches the other receiver. This effect is often referred to as the Sagnac effect. The third term is due to the differential light speed along the two paths. It causes the wave-front to be bent as if it is encountering a negative stellar aberration effect. These two terms will be addressed again later; but, first, the derivation is completed to show the result agrees with that obtained in equation (18).

Expanding the sine and cosine of the angle difference above gives:

$$\tau = \frac{\Delta\rho}{c} + \frac{b \cdot v}{c^2} Sin^2\ \delta - \frac{b}{c}\frac{v}{c} Sin\,\varphi\ Cos\,\delta\ Sin\,\delta + \frac{b \cdot v}{c^2} Cos^2\ \delta + \frac{b}{c}\frac{v}{c} Sin\,\varphi\ Cos\,\delta\ Sin\,\delta \tag{24}$$

The second and fourth terms combine, and the third and fifth terms cancel. The result is the same as equation (18). And, as was already shown in equation (19), this ether-drift effect cancels the clock-bias term.

Now let's return to the physical explanation for the terms in equation (23). If the directional dependence of the relative light speed gives rise to an orbital Sagnac effect together with a negative aberrational wave-front bending effect, then the clock-bias effect, which was shown to cancel it in the GPS section above, must be equivalent to a negative orbital Sagnac effect, together with an aberrational wave-front bending effect.

The quasar source plays no fundamental role in the analysis of effects. As stated earlier, any source-clock effects cancel out in the differencing process. Therefore, it is not significant which frame is ascribed to the source. Furthermore, from the geometry it becomes clear that the ether-drift effects are not a function of the distance to the quasar. Only the separation distance between the two receivers affects the ether-drift results.

At this point it is appropriate simply to report what the experimenters have done in order to get agreement between the earth-centered isotropic frame results and the sun-centered isotropic frame results. The relativists do apply the Sagnac effect to receivers which are moving with respect to the chosen frame of reference. In other words, the speed of light is always assumed to be isotropic with respect to the chosen frame, not with respect to observers or receivers. In the sun-centered frame, an adjustment is made for the orbital and spin motion of the second receiver after the signal is received at the first receiver. In the earth-centered frame, no orbital Sagnac effect is applied; but a spin Sagnac effect is. A second adjustment, which the practitioners make, is to apply aberrational effects if the chosen frame is moving with respect to the source. (They assume the quasar source is in the sun's frame.) But they do not apply aberration when it is the receiver rather than the frame which is moving, since this rain-drop aberration (receiver moving with respect to the isotropic-light-speed frame) is unknown in special relativity; and, in any case, the VLBI dish antennas would not be affected by this ray-bending-only type of aberration.

With these adjustments, the special theory advocates get the same VLBI results in the earth-centered frame as they get in the sun-centered frame. The orbital Sagnac effect goes away; but, in its place, an aberrational bending effect is added. Note that this difference can be blamed on the clock bias between the two isotropic-light-speed frames. As shown above, the clock bias causes a wave-front-bending aberration effect and the negative of an orbital Sagnac effect. Thus, when the bias is added to the results in the sun-centered frame, it cancels the orbital Sagnac effect and induces the wave-front bending aberrational effect.

Note the options which are available: (1) the VLBI data does give valid solutions in the absolute simultaneity sun-centered frame; (2) the VLBI data does fit an earth-centered absolute simultaneity frame if wave-front bending can be explained; and, (3) the VLBI data does give valid solutions using the frame of the cosmic background radiation if clocks are slowed by their velocity through that frame. Since the sun-centered frame is essentially moving at a constant velocity relative to the cosmic background frame, it is essentially impossible using VLBI to detect the differences between options (1) and (3). The dipole thermal distribution of the CBR argues persuasively for option (3). Option (2) is the option which was proposed in *Escape from Einstein*, [7] but I have been forced to abandon that choice since I cannot find any mechanism by which the required wave-front bending can be generated. In the light of all the evidence, option (3) seems to be the only valid choice.

In fact, there is other evidence that the wave-front bending and absence of the Sagnac effect in the earth-centered frame is due to the clock-biasing effects of velocity and that an ether drift velocity actually exists in the earth-centered frame. First, the gradient of the solar gravitational effects upon clocks on the surface of the earth is such that the clocks will speed up and slow down in precisely the correct way to retain the appropriate up-wind and down-wind clock biases. Thus, the clocks must be biased or else the solar gravitational effects would become apparent.

Second, as Charles Hill [8] has shown, clocks on the earth clearly vary their rate as the speed of the earth around the sun varies. Earth clocks run slower when the earth's speed increases and the earth's distance from the sun is decreased near perihelion. The earth's clocks run faster near aphelion. This variation must be counteracted via an ether drift effect else it could be detected in GPS and VLBI experiments.

Third, the ray-bending effect is real whether or not the chosen isotropic frame is the receiver-centered, earth-centered or the sun-centered frame. It is impossible to choose a different frame and thereby avoid tilting a telescope the proper amount to account for the stellar aberration. If huge tubes could be attached to the VLBI radio telescopes, they would undoubtedly need to be tilted to account for aberration even in the sun-centered frame where no wave-front bending aberration is used. This would provide direct evidence for non-SRT ray-bending aberration. If the clock biases in the earth-centered frame were removed, the Sagnac orbital effect from ether drift would become apparent and the physical absence of wave-front bending would also become apparent. The indirect evidence is compelling. The SRT imposed wave-front bending is an artifact of clock biases which arise either from requiring isotropic light speed in the chosen frame or (the equivalent) which arise from the integration of the clock offset due to velocity through the absolute frame.

Conclusion

The only direct evidence for a unique isotropic light-speed frame arises from the dipole thermal distribution of the CBR. In most experiments the effects of ether drift are directly canceled by a corresponding clock-velocity effect. Specific analysis of spinning Mossbauer, GPS and VLBI experiments reveal the cancellation mechanisms. However, in each case, the evidence for an independent clock effect provides strong indirect evidence for the presence of an ether-drift velocity.

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