An Aether Perspective on Stellar Aberration

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Abstract. *It has been known for nearly three centuries that, to view a clear image of a star through a telescope, it is necessary to tilt the telescope slightly forward in the direction of the earth's motion, a phenomenon known as "stellar aberration." Normally explained by mainstream physics without the presence of an aether medium for light transport and with relativistic corrections due to time dilation/length contraction via Lorentz transforms, this article examines stellar aberration from the perspective of an aether presence, including both a stationary and fully entrained aether, as well as the intermediate case of a partially entrained ("dragged") aether. Comparison is made with the parallel cases without an aether, with the option to allow light to acquire its source velocity.*

Key Words: Stellar aberration, (James) Bradley, telescope, aether, light

1. INTRODUCTION

"In 1725 James Bradley … began observations … [u]sing a telescope attached to a chimney so that it pointed nearly vertically[. H]e changed the position of the telescope very slightly, and very accurately measured its change in position using a screw and plumb-line; and over the course of a year or so found that the star did indeed vary in position … [T]he apparent positions … shifted *in the direction of the Earth's motion*, … the same for every star in a given region, regardless of its distance." [1] While this "stellar aberration" is explained by mainstream physics relativistically via time dilation/length contraction using Lorentz transforms, alternate theories have been proposed (e.g., [2 and 3]). This article examines stellar aberration in the presence of an aether - stationary, fully entrained and partially entrained ("dragged") - to show that the tilting of the telescope in the direction of earth's motion is consistent with either a stationary or partially entrained ("dragged" aether). For comparison, it then examines the parallel cases without an aether, with the option to allow light to acquire its source velocity.

2. CASE 1: STATIONARY STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C THROUGH STATIONARY AETHER

Consider Figure 1, where a stationary star pulses once, sending out a spherical (displayed as circular in two dimensions) light wave at speed c through a stationary aether. Relative to the star (and stationary aether), a telescope is moving at constant speed v as shown such that the light pulse through the aether reaches the top of the telescope when it is in the second position, as shown on the left portion of the figure. During the time it takes for that pulse to travel the length of the telescope to reach the bottom (eyesight), the telescope continues to move with speed v to the third position on the left. As shown, the telescope when vertical no longer aligns with the star. Now consider the right portion of the figure, where the telescope has been tilted forward in the direction of motion. Again, the light pulse reaches the top of the telescope when it is in the second position, now slightly to the right of previous (i.e., in the left portion of the figure). During the time it takes for that pulse to reach the bottom (eyesight), the telescope continues to move left with speed v to the third position. However, now it is aligned with the star. That is, by tilting the telescope forward to compensate for its motion relative to the star and stationary aether, the star's image can be clearly seen.

To put some numbers to this, assume a telescope of length 100 m = 0.100 km is in orbit above the Earth and moving to the left at maximum constant speed v = 0.003c, derived as follows. The orbital speed of an object about the equator ≈ 8 km/s. [4] Earth's rotational speed at the equator ≈ 0.5 km/s. [5] Earth's speed of revolution about the sun ≈ 30 km/s. [6] The sun's speed of revolution about the galaxy ≈ 230 km/s. [7] The Milky Way Galaxy's speed through "space" ≈ 580 km/s. [8] Combining these yields a total maximum orbital speed through "space" ≈ 850 km/s, rounded to 900 km/s, or 0.3% light speed c (3.00×10^5 km/s). Note that this approximation would hold even for the fastest man-made object ever launched.

The record holder is … the New Horizons mission to Pluto and the Kuiper belt. Launched by NASA in 2006, it shot directly to a solar system escape velocity. This consisted of an Earth-relative launch of 16.26 kilometers a second (that's about 36,000 miles per hour), plus a velocity component from Earth's orbital *motion (which is 30 km/s tangential to the orbital path). Altogether this set New Horizons barreling off into the solar system with an impressive heliocentric speed of almost 45 km/s or 100,000 miles per hour."* [9]

With light speed c = $3.00x10^5\frac{km}{s}$, it will take $t = 0.100\ km/3.00x10^5\frac{km}{s} = 3.33x10^{-7}s,\ or\ 0.333\mu s$, to travel the length of the telescope. Over this interval, the telescope will have traveled $d = (3.33x10^{-7}s)(900\frac{km}{s}) = 3.00x10^{-4}km$ farther. Therefore, to view the star when the aether is completely stationary (see Figure 2), the telescope needs to be tilted forward to account for its motion by $\theta = \tan^{-1}\frac{3.00x10^{-4}km}{0.100km} = 0.00300$ rad, or 0.172 deg.

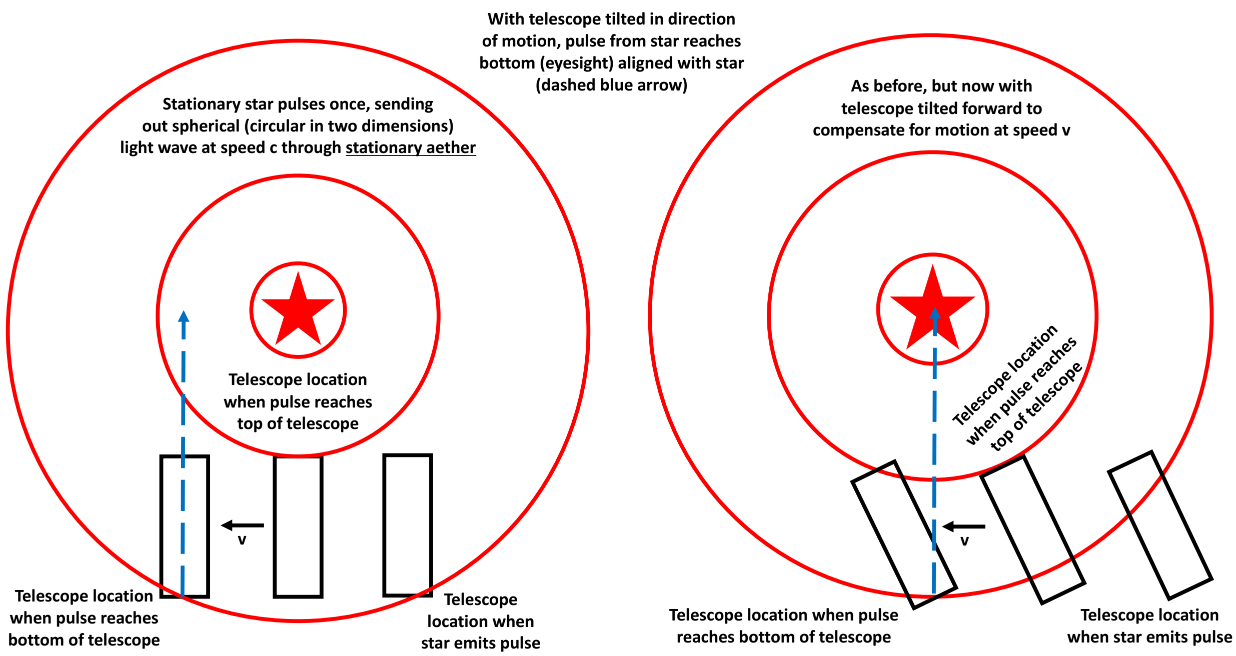

Figure 1. Telescope Moving with Constant Speed v relative to Stationary Star and Aether

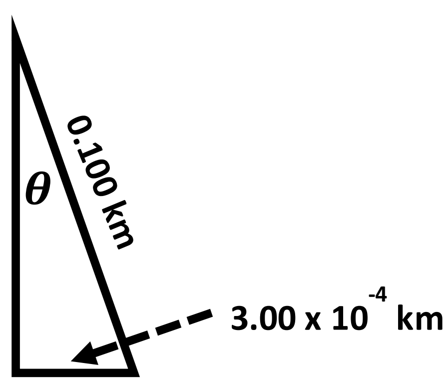

Figure 2. Geometry for Angle of Telescope Tilt

3. CASE 2: STATIONARY STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C THROUGH FULLY ENTRAINED AETHER

Unlike Case 1, the telescope now moves with a fully entrained aether shown as a green sphere (circle). When the pulse from the star reaches the top of the telescope (second position), it pulses the telescope's aether (shown as a smaller, hollow star), initiating another spherical (circular) light wave at speed c (dashed sphere [circle]) that travels down the telescope to reach the eyesight at the bottom (a smaller, hollow star again), such that the star's image is seen without tilting the telescope (third position on the left).

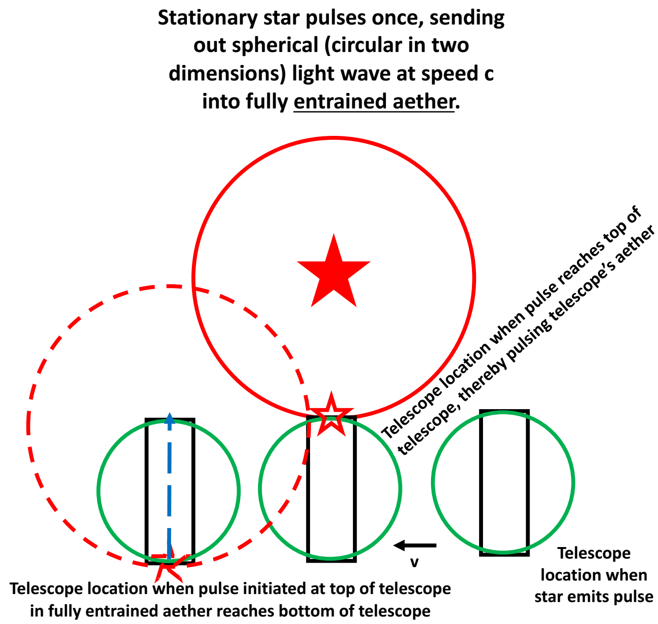

Figure 3. Telescope Moving with Constant Speed v relative to Stationary Star but with Fully Entrained Aether

4. CASE 3. STATIONARY STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C THROUGH PARTIALLY ENTRAINED ("DRAGGED") AETHER

Intermediate between Cases 1 and 2, the telescope now moves with a partially entrained ("dragged") aether moving at speed u < v, shown as green arrows in Figure 4. When the pulse from the star reaches the top of the "dragged" aether (first position), it pulses that aether (shown as a smaller, solid hollow star), initiating another spherical (circular) light wave at speed c. This (dotted sphere [circle]) propagates until reaching the top of the telescope (smaller, dotted hollow star) as the telescope has proceeded to the left at speed v, partially "catching up" to the aether pulse also proceeding to the left, but at speed u < v (second position). Finally, the pulse reaches the eyesight at the bottom (smaller, dashed hollow star), such that the star's image is seen after tilting the telescope forward, but to a lesser degree than for the stationary aether (third position on the left), as follows. For example, assuming $u = \frac{1}{3}v \approx \frac{1}{3}(900\frac{km}{s}) \approx 300\frac{km}{s},\ i.e.,\ 0.001c,$ while it will again take $t = 0.100\ km/3.00x10^5\frac{km}{s} = 3.33x10^{-7}s,\ or\ 0.333\mu s$, to travel the length of the telescope, now the telescope will have traveled only $d = t(v - u) = (3.33x10^{-7}s)(900\frac{km}{s} - 300\frac{km}{s}) = 2.00x10^{-4}km$ farther relative to the partially entrained ("dragged") aether. Therefore, to view the star when the aether is partially entrained ("dragged"), the telescope needs to be tilted forward by only $\theta = \tan^{-1}\frac{2.00x10^{-4}km}{0.100km} = 0.00200$ rad, or 0.115 deg, compared to 0.00300 rad (0.172 deg) for the stationary aether (Case 1). Similarly, for $u = \frac{2}{3}v \approx \frac{2}{3}(900\frac{km}{s}) \approx 600\frac{km}{s},\ i.e.,\ 0.002c,$ the telescope will have traveled $d = (3.33x10^{-7}s)(900\frac{km}{s} - 600\frac{km}{s}) = 1.00x10^{-4}km$ farther relative to the partially entrained ("dragged") aether, requiring the telescope to be tilted forward to account for its motion by only $\theta = \tan^{-1}\frac{1.00x10^{-4}km}{0.100km} = 0.00100$ rad, or 0.0573 deg, again less than for the stationary aether. Note that Case 3 reduces to the previous two at the extremes. If the aether is stationary (u = 0) as in the Case 1, the telescope must be tilted forward at 0.00300 rad (0.172 deg); for the fully entrained aether (u = v) as in Case 2, no tilt of the telescope is needed.

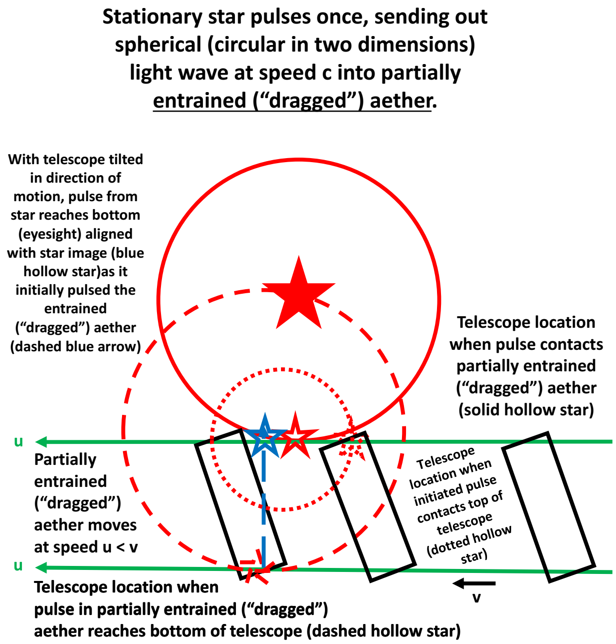

Figure 4. **Telescope Moving with Constant Speed v relative to Stationary Star but with Partially Entrained ("Dragged") Aether**

5. CASE 4. MOVING STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C WITHOUT ACQUIRING SOURCE VELOCITY

This case, shown in Figure 5, parallels Case 1, except that now the star is moving to the right with velocity u and there is no aether. Comparison with Figure 1 from Case 1 indicates parallel results, i.e., to observe the star clearly, the telescope must be tilted forward in its direction of motion by 0.00300 rad, or 0.172 deg, as in Figure 2. Based solely on observation, the parallel results for Cases 1 and 4 would not permit one to distinguish between them as to an aether's presence.

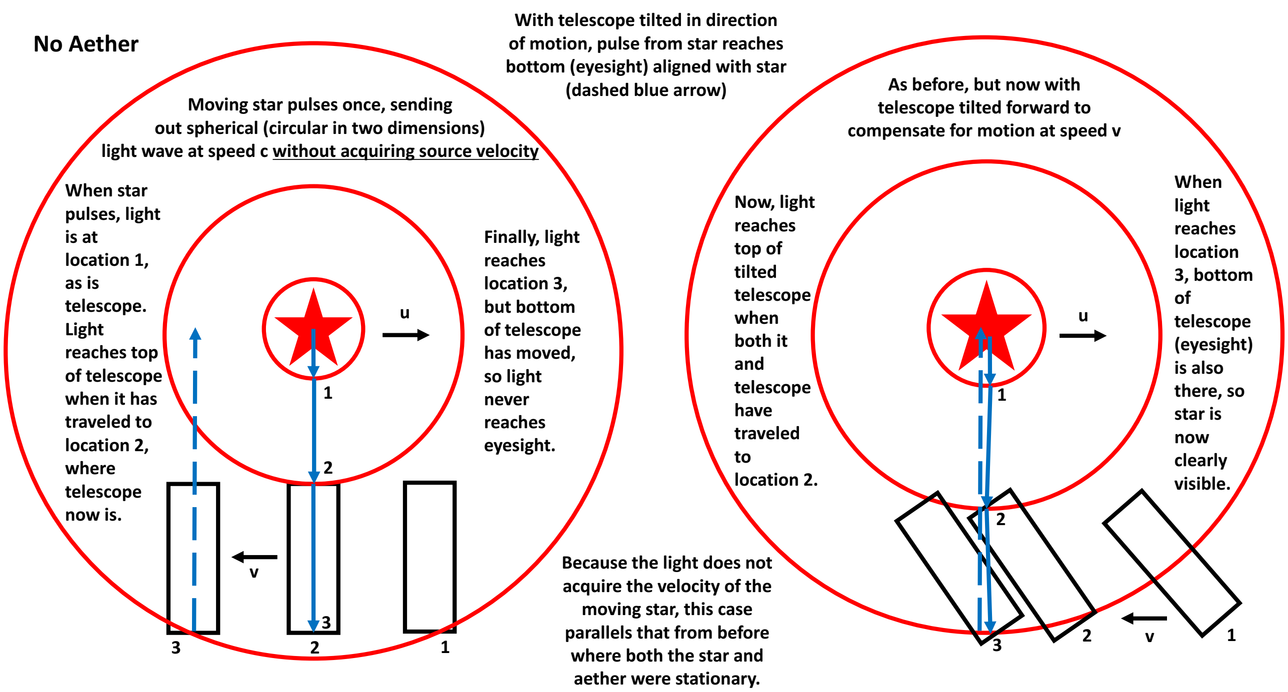

Figure 5. Telescope Moving with Constant Speed v Relative to Moving Star without an Aether nor with Light Pulse Acquiring Source Velocity

6. CASE 5. MOVING STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C WHILE ACQUIRING TOTAL SOURCE VELOCITY

Unlike Case 4, the light pulse is now assumed to acquire the total velocity of its source, i.e., the star's velocity u. "The Milky Way … [has] a diameter between 150,000 and 200,000 light-years (ly) ... The Solar System is located at a radius of about 27,000 light-years …" [10] Assume the observed star lies in a similar galaxy, say the maximum 200,000 ly in diameter, but at the outer rim, such that its speed is maximum. Since galactic rotation often involves fairly constant angular velocity ("pinwheel"), the speed u of this star if the galaxy rotates at the same speed as the Milky Way (ω) would be: $\omega = v_1/r_1 = v_2/r_2 \rightarrow v_1 = v_2\frac{r_1}{r_2}$. For our sun at $r_1 \approx$ 27,000 ly with speed $v_1 \approx 230\ \frac{km}{s}$, the observed star at $r_2 = \frac{200{,}000\ ly}{2} = 100{,}000$ ly has $u \approx (230\frac{km}{s})\frac{100{,}000 ly}{27{,}000\ ly} \approx 850\frac{km}{s}$, which rounds up to 900 $\frac{km}{s}$, for convenience (0.003c). Having acquired the star's total velocity, the light pulse travels at speed $\sqrt{c^2 + u^2} = \sqrt{c^2 + (0.003c)^2} = 1.0000045c = 3.00x10^5\frac{km}{s}$. (To several significant digits, the speed has increased from 2.998 to 2.99801 x $10^5\ \frac{km}{s}$, too small to make a readily measurable difference.) Thus, it will take $t = 0.100\ km/3.00x10^5\frac{km}{s} = 0.100\ km/3.00x10^5\frac{km}{s}$ =3.33 x 10^{-7} s, or 0.333 μs to travel the length of the telescope. Over this interval, the telescope will have traveled $d = (3.33x10^{-7}s)(900\frac{km}{s}) = 3.00x10^{-4}km$ farther. Therefore, to view the star when its light pulse acquires the star's velocity, the telescope needs to be tilted forward to account for its motion by $\theta = \tan^{-1}\frac{3.00x10^{-4}km}{0.100km} = 0.00300$ rad, or 0.172 deg. This essentially parallels Case 1 where the star was stationary and pulsed into a stationary aether, as well as Case 4 where there is no aether nor does the light pulse acquire its source velocity. Again, it would be virtually impossible to distinguish among Cases 1, 4 and 5 based solely on the observed tilt angle.

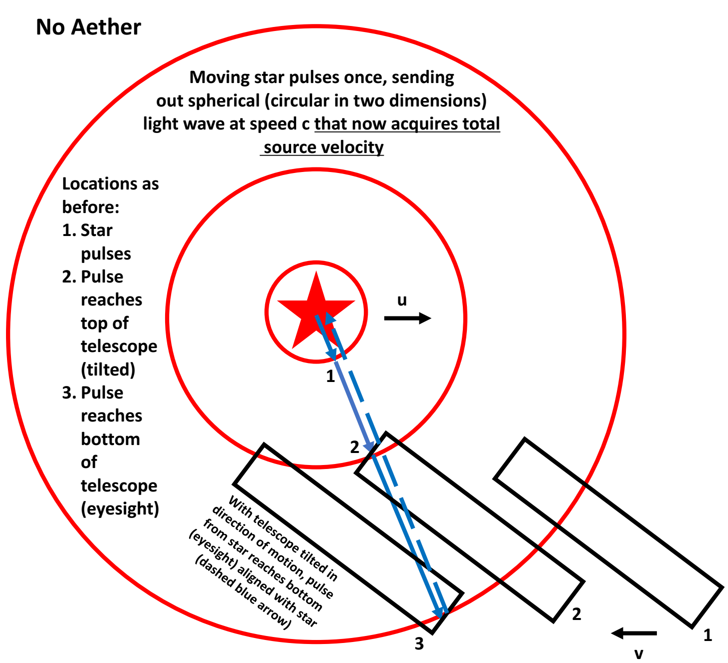

Figure 6. Telescope Moving with Constant Speed v Relative to Moving Star without an Aether while Acquiring Total Source Velocity

7. CASE 6. MOVING STAR PULSES ONCE, SENDING OUT LIGHT WAVE AT SPEED C WHILE ACQUIRING PARTIAL SOURCE VELOCITY

To illustrate the intermediate case between the extremes with no aether and the light pulse acquiring none vs. all of the star's velocity, Figure 6 again applies (except that now the pulse acquires only part of the source velocity). The only difference would be that the pulse now acquires a speed w < u, such that it now travels at only $\sqrt{c^2+w^2}$. For $w = \frac{1}{3}u \approx \frac{1}{3}(900\frac{km}{s}) \approx 300\frac{km}{s}$, $i.e.$, $0.001c$, the pulse speed becomes $\sqrt{c^2+(0.001c)^2} = 1.0000005c = 3.00x10^5\frac{km}{s}$. (To several significant digits, the speed has increased from 2.998 to 2.998001 x 10^5 $\frac{km}{s}$, too small to make a readily measurable difference.) Thus, it will take $t = 0.100\ km/3.00x10^5\frac{km}{s} = 3.33x10^{-7}s,\ or\ 0.333\mu s$, to travel the length of the telescope, which still travels 3.00 x 10^{-4} km farther. At $w = \frac{2}{3}u \approx \frac{2}{3}(900\frac{km}{s}) \approx 600\frac{km}{s}$, $i.e.$, $0.002c$, the pulse speed becomes $\sqrt{c^2+(0.002c)^2} = 1.000002c = 3.00x10^5\frac{km}{s}$. (To several significant digits, the speed has increased from 2.998 to 2.998006 x 10^5 $\frac{km}{s}$, too small to make a readily measurable difference.) Again, it will take $t = 0.100\ km/3.00x10^5\frac{km}{s} = 3.33x10^{-7}s,\ or\ 0.333\mu s$, to travel the length of the telescope, which still travels 3.00 x 10^{-4} km farther. Therefore, unlike the aether case where there was a measurable difference in the tilt angle for the telescope between stationary and partially entrained ("dragged") aether, there is effectively no difference without an aether even if light acquires at least a portion of the source velocity, so long as that velocity is << c.[1] Still, it is necessary to tilt the telescope at essentially the same angle (0.00300 rad = 0.172 deg) as in Cases 1, 4 and 5 to observe the star clearly.

8. CONCLUSION

Bradley showed that it was necessary to tilt the telescope forward in its direction of motion relative to the essentially stationary star to obtain a clear image. As an alternative to the mainstream explanation of this "stellar aberration" using relativistic time dilation/length contraction via Lorentz transforms, this article examines the phenomenon as if an aether medium for light transport were present – including the extreme cases of a stationary vs. fully entrained aether, and the intermediate case for a partially entrained ("dragged") aether. Results indicate consistency with either a stationary or partially entrained ("dragged") aether, depending upon the degree of tilting

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[1] Consider the following three extreme cases. First, assume the star travels with velocity u = c, such that its light pulse, if acquiring this velocity, travels at speed $\sqrt{c^2+c^2} = c\sqrt{2} = 1.414c$, i.e., $4.24x10^5\frac{km}{s}$. Its travel time down the length of the telescope would drop only from t = 3.33 x 10^{-7} s to $t = 0.100\ km/4.24x10^5\frac{km}{s} = 2.36x10^{-7}s$, or 0.236μs. Thus, the telescope would travel $(2.36x10^{-7}s)(900\frac{km}{s}) = 2.12x10^{-4}km$ farther. The tilt angle would decrease only from 0.00300 rad (0.172 deg) to $\tan^{-1}\frac{2.12x10^{-4}km}{0.100\ km} = 0.00212$ rad, or 0.126 deg, comparable to Case 3 with a partially entrained ("dragged") aether moving at 0.001c. Next, assume the star travels in the direction of Earth, first with speed u $\approx 900\frac{km}{s}$ (i.e., 0.003c), then with u = c. In the first instance, the time for its light pulse, acquiring the star's full velocity, to traverse the tilted telescope would be $t = 0.100\ km/(3.00\ x\ 10^5\frac{km}{s} + 900\frac{km}{s}) = 3.326x10^{-7}s$, about the same as before, i.e., 0.333μs, corresponding to the same tilt angle of 0.00300 rad, or 0.172 deg. In the second instance, the light pulse now traveling at 2c would traverse the telescope in t = $0.100\ km/([2][3.00\ x\ 10^5\frac{km}{s}]) = 1.67x10^{-7}s$, i.e., twice as fast as before. Now the telescope would travel only half the distance farther, or $(900\frac{km}{s})(1.67x10^{-7}s) = 1.50x10^{-4}km$, reducing the necessary tilt angle by half to $\tan^{-1}\frac{1.50x10^{-4}km}{0.100\ km} = 0.00150$ rad, or 0.0860 deg. Interestingly, even this most extreme case requires more tilt than for the earlier partially entrained ("dragged') aether of Case 3 when the aether speed was $600\frac{km}{s}$, or 0.002c (i.e., 0.00100 rad, or 0.0573 deg).

that would be necessary. However, note the following. So long as the telescope must be tilted forward to cleanly observe the star, it will be difficult to distinguish between light carried by a stationary or partially entrained ("dragged") aether vs. light that travels without an aether, regardless of whether it acquires its source velocity (so long as that velocity is << c).

9. REFERENCES

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