Newtonian explanation of GPS clock correction

Testing gravitationally dragged aether on GPS

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November 2020, Berlin

Abstract

We will show that with help of the gravitationally dragged aether concept [1], relativistic [2] clock corrections on GPS satellites can be computed precisely.

Content

1. Introduction

Subsequent to the author's paper „Gravity and Light Speed - Testing gravitationally dragged aether on stellar aberration and Sagnac effect" [1], we will take a closer look to the relativistic clock correction of GPS satellites and once again verify the concept of the gravitationally dragged aether theory. This concept is based on the assumption that electromagnetic waves in general will be affected by gravity similarly to normal matter, i.e. celestial bodies will drag the light along their gravity.

2. Atomic clocks and second order effect on speed addition

Behavior of atomic clocks is similar to the Michelson Morley [3] interferometer. Coherent microwaves run back and forth within a resonator cavity, whilst atoms will be excited and counted.

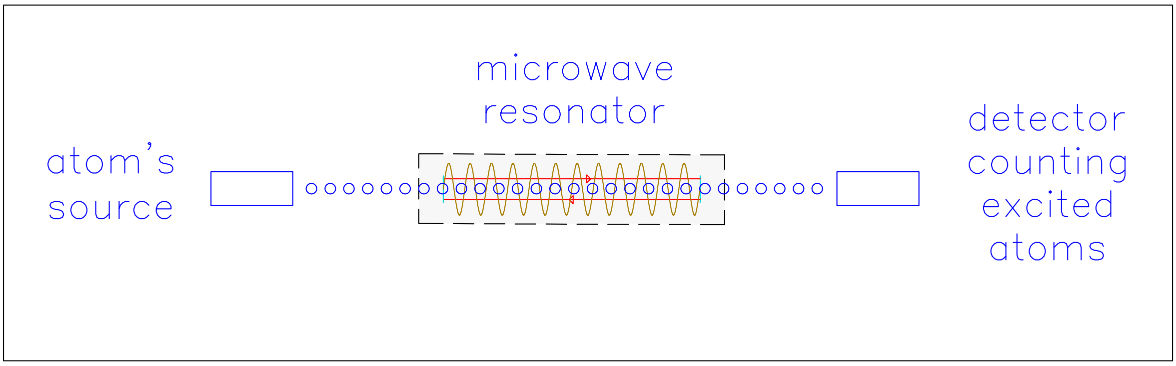

Fig. 1: Atomic clock setup

Runtimes of the microwaves within the cavity underlay second order effects on speed addition as shown in the author's paper [1]. For now, we will only look at the rotational speed of the satellite, since in a dragged aether setup all other velocities are irrelevant, as long as light is dragged along properly with the reference system. In the following sketch the relevant velocities are shown:

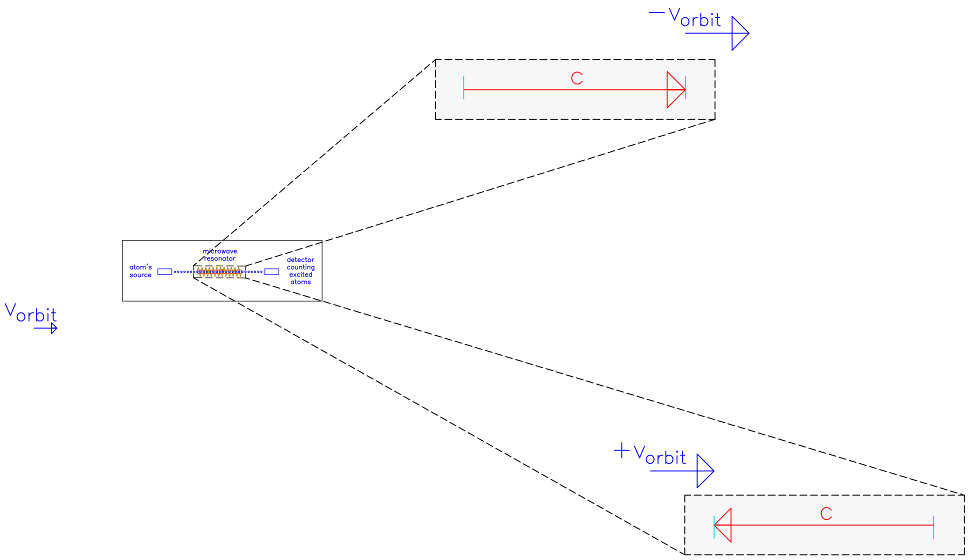

Fig. 2: Velocities in dragged aether

If we only had to deal with the rotational speed of the satellite against the stationary gravitational field of earth, the following formula will have to be applied according to the author's paper [1]:

$$\boxed{\Delta t = \frac{2l}{c} \cdot \frac{v_{orbit}{}^2}{\left(c^2 - v_{orbit}{}^2\right)}}$$

We now use the following values:

l: 1m (Distance of the resonator's mirrors. Irrelevant for the result because it is cancelling out)

c: 299.792.000 m/s (speed of light)

v_{orbit}: 3.874 m/s (orbital speed of satellite)

And the result is:

$$\Delta t = \frac{2l}{c} \cdot \frac{v_{orbit}{}^2}{c^2 - v_{orbit}{}^2} = \frac{2 \cdot 1m}{299.792.000m/s} \cdot \frac{\left(3.874m/s\right)^2}{\left(299.792.000m/s\right)^2 - \left(3.874m/s\right)^2} \approx 1{,}114 \cdot 10^{-18} s$$

At 1m length the time for one complete roundtrip is:

$$t = \frac{l}{c} = \frac{1m}{299.792.000m/s} \approx 6{,}671 \cdot 10^{-9} s$$

Therefore we have the following count of roundtrips per 24h (any size of l is cancelling out at this point):

$$U \approx \frac{60 \cdot 60 \cdot 24s}{6{,}671 \cdot 10^{-9} s} \approx 1{,}2951 \cdot 10^{13}$$

Therefore the diurnal time gain is:

$$\Delta t(24h) = \Delta t \cdot U = 1{,}114 \cdot 10^{-18} s \cdot 1{,}2951 \cdot 10^{13}$$

$$\boxed{\Delta t(24h) \approx 14{,}43\mu s}$$

Which is precisely double the amount of the given relativistic time dilation of 7,2µs for GPS satellites according to Special Relativity.

3. Situation of gravitational influences

Unfortunately the above is just half of the bill. In a gravitationally dragged aether surrounding we will have to take into consideration, that gravitational influences of the involved celestial bodies vary depending on the distance between the masses and the satellite. The relationship of the gravitational influences determine how much the light is being dragged.

If the satellite was standing on earth's surface, we would have the following picture of relevant gravitational effects according to Newton:

$$a = G \cdot \frac{m_1 + m_2}{r^2}$$

Influence of sun (taking m_1=100kg for the satellite, m_2=mass of sun, r=distance between sun and earth):

$$a_{sun} = G \cdot \frac{m_1 + m_2}{r^2} = 6,6743 \cdot 10^{-11} \frac{m^3}{kg \cdot s^2} \cdot \frac{100kg + 1,989 \cdot 10^{30} kg}{1,496 \cdot 10^{11} m} = 5,932 \cdot 10^{-3} \frac{m}{s^2}$$

Influence of earth (taking m_1=100kg for the satellite, m_2=mass of earth, r= radius of earth):

$$a_{earth} = G \cdot \frac{m_1 + m_2}{r^2} = 6,6743 \cdot 10^{-11} \frac{m^3}{kg \cdot s^2} \cdot \frac{100kg + 5,972 \cdot 10^{24} kg}{6,371 \cdot 10^{6} m} = 9,81 \frac{m}{s^2}$$

And the gravitational dragging lag of light on surface of earth, as part of v_{CMB}:

$$v_{gravity} = v_{CMB} \cdot \frac{a_{sun}}{a_{earth}} = 368.000 \frac{m}{s} \cdot \frac{5,932 \cdot 10^{-3} \frac{m}{s^2}}{9,81 \frac{m}{s^2}} \approx 222 \frac{m}{s}$$

Compared to the orbital speed of the satellite of 3.874 m/s this seems not much of relevance.

But now we do the same calculation for the satellite's orbit (influence of sun as before):

$$a_{sun} = 5,932 \cdot 10^{-3} \frac{m}{s^2}$$

Influence of earth (r= radius of satellite's orbit):

$$a_{orbit} = G \cdot \frac{m_1 + m_2}{r^2} = 6,6743 \cdot 10^{-11} \frac{m^3}{kg \cdot s^2} \cdot \frac{100kg + 5,972 \cdot 10^{24} kg}{2,6571 \cdot 10^{7} m} = 0,56456 \frac{m}{s^2}$$

And the gravitational dragging lag of light on the satellite's orbit, as part of v_{CMB}:

$$v_{gravity} = v_{CMB} \cdot \frac{a_{sun}}{a_{earth}} = 368.000 \frac{m}{s} \cdot \frac{5,932 \cdot 10^{-3} \frac{m}{s^2}}{0,56456 \frac{m}{s^2}} \approx 3.828 \frac{m}{s}$$

Compared to the orbital speed of the satellite of 3.874 m/s this indeed is of relevance.

4. Speed component

Now the task has to be done finding out, from which direction this additional speed component will come during a half rotation of the satellite on its orbit:

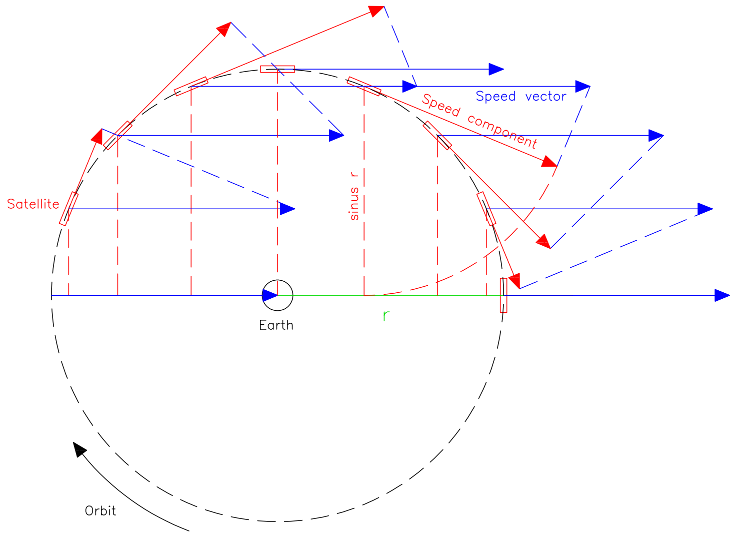

Fig. 3: Velocity vector

We can see, that the speed component of the speed vector in the direction of the resonator's axis is always the sinus of each angle (highlighted in red).

To obtain the average applicable speed component for half a roundtrip we have:

For the length of the half circle arch:

$$f_1(r) = r \cdot \pi$$

For the component of the speed vector:

$$f_2(r) = r \cdot \sin(r)$$

Now we have to integrate both in order to get the average of a half circle, i.e. the area below the arch vs. the area below the sinus curve:

$$\int_0^\pi f_1(r) = \frac{1}{2} r^2 \cdot \pi$$

$$\int_0^\pi f_2(r) = \frac{1}{2} r^2 \cdot \left(-\cos(\pi) + \cos(0)\right) = \frac{1}{2} r^2 \cdot \left(-(-1) + 1\right) = r^2$$

And the relation of both:

$$\int_0^\pi \frac{f_1(r)}{f_2(r)} = \frac{1/2\, r^2 \cdot \pi}{r^2} = \frac{1}{2}\pi$$

This means that over a half circle period the applicable speed component is π/2 of the speed vector.

4. Final calculation

Now we will take the rotational speed of the satellite on its orbit together with the gravitational light dragging influence:

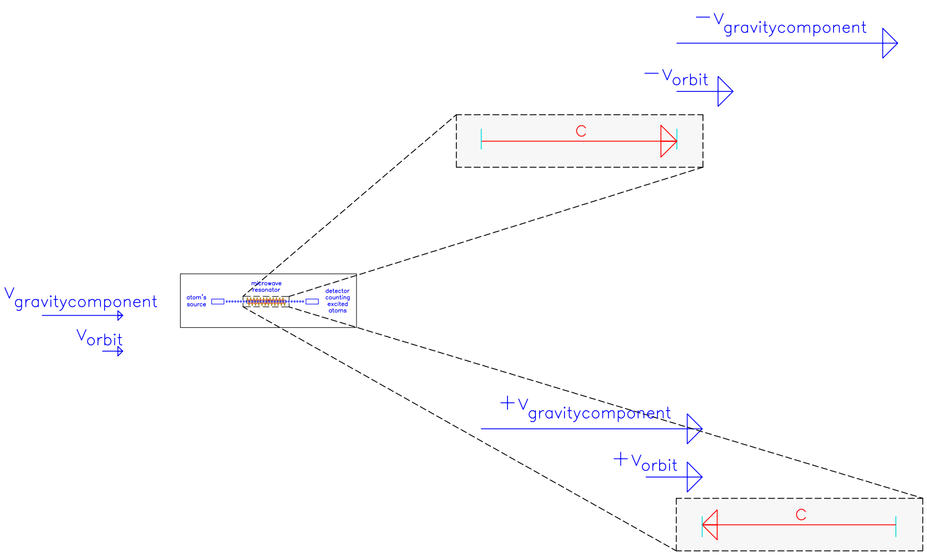

Fig. 4: Velocities

The formula is again obtained from the author's paper [1], but instead of v_{CMB} we use the component of $v_{gravitycomponent}$ from above that is lagging to follow earth's gravity:

$$\boxed{\Delta t = \frac{2l}{c} \cdot \frac{\left(v_{orbit} + v_{gravitycomponent}\right)^2}{\left(c^2 - \left(v_{orbit} + v_{gravitycomponent}\right)^2\right)}}$$

l: 1m (irrelevant for the result)

c: 299.792.000 m/s

v_{orbit}: 3.874 m/s

$v_{gravitycomponent}$: 3.828 m/s / π/2 = **2.437 m/s**

For the second half circle actually it will be -π/2, but also the formula will be $(v_{orbit} - v_{gravitycomponent})^2$, leading to the same result all together:

$$\Delta t = \frac{2l}{c} \cdot \frac{\left(v_{orbit} + v_{gravitycomponent}\right)^2}{\left(c^2 - \left(v_{orbit} + v_{gravitycomponent}\right)^2\right)} = \frac{2 \cdot 1m}{299.792.000 m/s} \cdot \frac{\left(3.874 m/s + 2.437 m/s\right)^2}{\left(299.792.000 m/s\right)^2 - \left(3.874 m/s + 2.437 m/s\right)^2} \approx 2{,}9562 \cdot 10^{-18} s$$

Therefore the diurnal time gain is (Count of roundtrips per 24h as per chapter 2):

$$\Delta t(24h) = \Delta t \cdot U = 2,9562 \cdot 10^{-18} s \cdot 1,2951 \cdot 10^{13}$$

$$\boxed{\Delta t(24h) \approx 38,285 \mu s}$$

Calculation of GPS total relativistic clock time correction for both Special and General Relativity [2] give an amount of time gain of 38,5µs, using the same above values for masses, speeds, distances etc.

4. Conclusion

It was shown that GPS clock correction is fully explainable by Newtonian physics and the assumption of a gravitationally dragged aether. It has to be emphasized that if any of the underlying values for distances and masses of celestial bodies would be slightly different, the result would quickly differ by a pile of microseconds.

Moreover, if orbital speed of earth would also be incorporated in above calculations, the 38,29 µs gain would have a further annual difference of +/- 2,39µs.

References and Acknowledgments (in order of appearance):

[1] F. M. Schmitt, "Gravity and Light Speed," Berlin, 2020.

[2] Einstein, Albert, Zur Elektrodynamik bewegter Körper, Annalen der Physik und Chemie. 17, 1905, S. 891–921, 1905.

[3] Michelson, A. A., Morley, E.W, On the Relative Motion of the Earth and the Luminiferous Ether, Bde. %1 von %21887, 34 (203): 333–345 1881, American Journal of Science, 1887.