Re: I Owe Einstein an Apology. Sorry Albert!

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From: Henri Wilson (*H_at_..(Henri*)
Date: 12/13/04

Date: Mon, 13 Dec 2004 21:30:39 GMT

On Mon, 13 Dec 2004 15:28:17 +0100, "Paul B. Andersen"
<paul.b.andersen@deletethishia.no> wrote:

>Excuse me for butting in, but I find so much
>confusion about the GPS in this thread that I
>feel the need for clearing up a few misconceptions.
>
>
>jahn wrote:
>> "The Ghost In The Machine" wrote:
>>>jahn wrote:
>>>>"The Ghost In The Machine" wrote:
>>>>> jahn wrote:
>>>>>>"The Ghost In The Machine" wrote:
>>>>>>>If the clocks are moving then SR predicts they will not remain
>>>>>>>synchronized.
>
>Clocks moving in a frame of reference will not
>generally stay synchronous in that frame,
>but they may do so in special cases.
>For example, clocks moving in a circle with
>the same speed will stay synchronous to each
>other in the "stationary frame". They will
>run slow compared to stationary clocks,

Who says?

>but they will stay in sync.
>This is the case in the GPS.
>All the GPS satellite clocks stay in sync
>to each other in the ECI frame because
>they all move in circular orbits with the
>same speed and at the same gravitational potential.

They all stay in synch with the ground clock, too, after they are initially
corrected for the 'free fall effect'.
.
>

>>>>>>SR predicts moving clocks can't keep good time?
>>>>>>I have two garden hoses an egg timer and a bag
>>>>>>of marbles that says they must be broken.
>>>>>>http://www.boulder.nist.gov/timefreq/time/commonviewgps.htm
>>>>>
*>>>>>The SR correction is t' = (t−vx/c^2) * gamma .*
>>>>
>>>>>The vx/c^2 is merely a reflection that the two clocks are
>>>>>communicating through speed−of−light (e.g., radio), but
>>>>>the gamma is the killer; gamma = 1/sqrt(1−v^2/c^2).
>
>The vx/c^2 is a reflection of the simultaneity of relativity.
>It has nothing to do with "communication through speed of light".
>
>>>>>It's a very slow killer, of course; the typical speed
*>>>>>of a spacecraft is on the order of 9 km/s = 3 * 10^−5 c, which*
*>>>>>results in a gamma of about 4.5 * 10^−10. The GPS delta is*
*>>>>>almost exactly this: 4.46 * 10^−10. However, this is at*
>>>>>best a very very rough estimate, just to give one the feel.
>>>>>It's also the wrong sign. :−)
>
>Which should tell you something. :−)
>
>It is actually quite simple to make a first order
>calculation of the rate of the GPS satellites.
>
>The relative difference in the rate of a clock in circular orbit
>compared to a clock on the surface of the Earth is according to GR
>to a first order approximation:
>(Approximation of the Schwarzchild solution)
>
>(f2 − f1)/f1 =
*> (G*M/(c^2*r1) − G*M/(c^2*r2)) − (0.5*v2^2/c^2 − 0.5*v1^2/c^2)*
>
>Where G = gravitational constant, M = mass of the Earth,
>r1 = radius of the Earth, r2 = radius of the orbiting clock's orbit,
>v1 = speed of the Earth clock in ECI frame,
>v2 = speed of the orbiting clock in ECI frame
>
*>Since we have G*M/r1^2 = g, acceleration at Earth's surface, we have:*
*>(G*M/(c^2*r1) − G*M/(c^2*r2)) = (g/c^2)*r1*(1−r1/r2)*
>
>Altitude of GPS satellites = 20200 km
>Orbital period = half sidereal day
*>Radius of the Earth r1 = 6.37*10^6 m*
*>Radius of GPS orbit r2 = 26.57*10^6 m*
>g = 9.81 m/s^2
>
>Inserting these numbers, we find that the rate difference
*>due to gravitation is: 5.28*10^−10 (+45.6 us/day)*
>

>So to the speed part:
*>v1 = 40000km/(23h 56m) = 4*10^7/86160 = 464 m/s*
*>v2 = 2*pi*r2/(11h 28m)= 3.87*10^3 m/s (−7.1 us/day)*
>
*>0.5*v2^2/c^2 = 0.83*10^−10*
*>0.5*v1^2/c^2 = 1.2*10^−12*
*>Thus the rate difference due to the speed will be: −0.82*10^−10*
>
*>The combined rate difference: (5.28−0.82)*10^−10 = 4.46*10^−10*
>Note that the orbiting clock runs _fast_.
>
>During one day, the difference in proper times will amount to:
*>4.46*10^−10*86400 s = 38.5*10^−6 s = 38.5 us*
>
>According to:
>http://vishnu.nirvana.phys.psu.edu/mog/mog9/node9.html
*>the factor used in the GPS satellites is 4.4647*10^−10.*
>
>>>>>An accurate clock left running for a year in a GPS orbit
>>>>>will gain about a hundredth of a second.
>
>You mean a "normal clock" not slowed down
*>by the factor 4.4647*10^−10?*
>Yes. It would gain ca. 14 ms a year.
>
>[..]
>>>>>(SR predicts loss
>>>>>of time, but then SR requires straight−line freespace
>>>>>travel. :−)). Therefore, GPS clocks are "broken" by
>>>>>design, coding in this adjustment factor −− and even
>>>>>then, they have to be steered from the ground using
>>>>>synchronization signals from the TAI.
>
>1. "GPS time" is a coordinated time where the coordinate
> system in question is stationary in the ECI−frame.
> The coordinate time is per definition such that
> clocks on the geoid will stay in sync (run at the same
> rate) with this coordinate time.
> "GPS time" is a theoretical time, derived from
> all the clocks in the system, that is all the satellite
> clocks and all the ground station clocks.
>
>2. This "GPS time" is steered so that it (but for a number
> of whole seconds) is equal to UTC. The spec says it should
> be within 1 us, but in actual practice, it differs but
> few ns. This difference is known by the system, and each
> satellite will transmit the difference GPS−time − UTC
> so that a receiver can calculate the correct UTC.
>ftp://tycho.usno.navy.mil/pub/gps/utcgps30.dat
>
>3. The GPS satellite clock are built to run slow

> (compared to a clock using the SI definition of a second)
*> by the factor 4.4647*10^−10 prior to launch.*
> In orbit, they will thus run synchronously to GPS−time.
>
>4. The precision of the clocks is in the order of 10^−13.
> That means that they during one day may drift off sync
> by several ns − or even tens of ns. The most that can
> be tolerated is a few tens of ns.
> (Less than 100ns at the very most)
>
>5. To correct for the latter, ground stations are monitoring
> the satellite clocks, and are uploading correctional data
> typically once a day. The "clock offset" is simply how
> much the clock is off sync. For some satellites, this may
> be up to milliseconds. The satelite clocks are not corrected,
> but the "clock offset" is transmitted together with the
> "clock time", and the receiver calculates the corrected time.
>
>>>>Indeed:
>>>>< GPS TIME STEERING
>>>>==========
>>>>GPS time is automatically steered to UTC(USNO) on a daily basis to keep
>>>>system time within one microsecond of UTC(USNO), but during the last
>>>>several years has been within 50 nanoseconds. The rate of steer being
>>>>applied is +/−1.0E−19 seconds per second squared.
>>>>ftp://tycho.usno.navy.mil/pub/gps/gpstt.txt
>
>Right.
>But note that as stated above. this is steering of
>the GPS−time, not of the individual satellites.
>You have two different coordinated time systems,
>each "living its own life" which should be made
>to run equal. The +/− 1.0E−19 seconds per second squared
>is the maximun "speed" with which the GPS time is changed.
>
>
>>>>It must take a REAL good mathematician to get 7 microseconds
>>>>per day out of that. ;−)
>
>.. and a real bad physicist to try. :−)
>
*>>>I get 38.53 microseconds per day out of the 4.46*10^−10 corrective factor.*
>>>It's a simple enough multiplication:
>>>
*>>>4.46*10^−10 sec/sec * 86400 sec/day*
>
>Right.
>
>> The altitude effect isn't cumulative.
>
>Utter nonsense.

>
> > That is, you can move
>> from Honolulu to Tibet and make one adjustment to the
>> length of a pendulum. You don't have to do it every day.
>
>But the error is still cumulative, isn't it? :−)
>
>> The 7 ns per day is for transverse doppler effect (less
>> frequently called the SR correction)
>
>3 orders of magnitude wrong.
>(But we will call this a typo.)
>
> > It was included in
>> the preset because it does save the receiver some calculating
>> (there may have been some political reason to have all
>> the "relativistic" effects in one synthezer too [shrug])
>> Anyway the 7ns error would accumulate if it represented
>> a clock rather than a propagtaion effect.
>
>Of course a rate error of 7 us/day would accumulate 7 us a day.
>
>> I think you can tell at a glance that +/−1.0E−19 steering
>> and +/− 50 ns / daily won't on the worst day add up to
>> the 7ns necessary to atrribute to an SR clock anomaly.
>
>This confusion is too gigantic to try to remedy. :−)
>You really have no clue whatsoever, have you jahn Sue?
>
>> It's all public information.
>> http://tycho.usno.navy.mil/gps_datafiles.html
>> http://tycho.usno.navy.mil/systime.html
>
>But you have no idea of what they mean?
>
>Paul

HW.

www.users.bigpond.com/hewn/index.htm