Re: GPS calculations

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From: Henri Wilson (*H_at_..(Henri*)
Date: 09/28/04

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Date: Tue, 28 Sep 2004 22:15:10 GMT
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On Tue, 28 Sep 2004 14:49:01 −0500, EjP <nospam@hackers.are.bad> wrote:

>xxein wrote:
>> For those confused by 46 us/day and 38 us/day, It depends on wether
>> you think the satellites orbit once a day or twice a day.
>>
>> It seems there is a lot of confusion both on this ng and the general
>> science archives.
>>
>> End.
>
>There is no confusion amongst those who know what they're talking
>about. The correction is 38 usec a day, based on a perturbative
>treatment which allows you to separate the "SR" and "GR" compoenents.
>If you do this, you get a 45 usec advance from the gravitational
>potential difference and a 7 usec slowing form the SR component,
>giving a net correction of 38 usec. This was calculated *long*
>before the satellites were launched and match observation exactly.
>
>Since the orbital period of GPS satellites is about 12 hours,
>the correction per period is about 19 usec. I'm not sure
>where your 46 usec comes from, except that it's close to the
>45 that one gets from a partial calculation.
>
>The calculation is actually pretty simple. I've appended it
>below. This version is a bit long because I was arguing with
>some kook that claimed all sorts of "extra" factors had been
>added, and I was showing that you can calculate the whole thing
>if you know the altitude and period of the satellite and
>the radius of the Earth.
>
> −E
>
>
>===============Details of GPS Calculation========================
>The altitude of the GPS sats are about 20,000 km, so their
>radius is 27,000 km. The observed period is 12 hours. From this you
>can work out that the velocity is

>
> v = 2*PI*R/T = 3.93 x 10^3 m/s
>
>This means that \beta = v/c = 1.31 x 10^(−5). The velocity at the
>surface
>of the earth is negligible compared to this, so the SR clock correction
>would come from
>
> \gamma = 1/sqrt{1−\beta^2} ~ 1 + .5*\beta^2 ~ = 1 + (8.5 x 10^(−11))
>
>so the orbiting clock would tick "slowly" by 1/gamma, or a fractional
>change of
>
> 8.5 x 10^(−11)
>
>and the clock would lose (86400)*(8.5 x 10^(−11)) = 7 x 10^(−6) s/day
>
>
>Now, move on to GR. Use
>
> v = sqrt(GM/R) to get GM = 4.2 x 10^14
>
>The GR gravity−only time dilation "gamma" is (look it up)
>
> \gamma = 1/sqrt{1 − 2GM/(Rc^2)} ~ 1 + GM/(Rc^2)
>
>So the difference between a clock ticking on Earth (R=Re=6.7E6) and one
>ticking in orbit
>(R=Ro=27E6) would be
>
> 1+GM/(Re*c^2)
> −−−−−−−−−−−−− ~ 1 + (GM/c^2)(1/Re − 1/Ro)
> 1+GM/(Ro*c^2)
>
>since the earth clock is deeper in the gravitational well, it would tick
>slowly and relative to it, the GPS clock would tick fast by a factor
>
> (GM/c^2)(1/Re − 1/Ro) = 5.23 x 10^(−10)
>
>so the clock would gain
>
> 86400*(5.23 x 10^(−10)) = 45 x 10^(−6) s/day
>
>so the net gain would be 45 − 7 = 38 microseconds, which is (strangely
>enough) EXACTLY the value they use, see
>http://www.phy.syr.edu/courses/PHY312.98Spring/projects/GPS/GPS.html
>

So what is it about movement or gravity wells that actually affects the way a
clock ticks?

You CDEFs all talk crap.

Just because light increases speed and incurs a doppler shift as it falls down
a gravity well, you think 'clock ticks' do the same.

Maybe PA's famous tick fairies are at it again....!

HW.

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