You can fool some of the people all of the time and all of the people
some of the time, but you cannot fool all of the people all of the time.
Abraham Lincoln (USA, 1809-1865)

For what is a correction of 38 microseconds introduced into GPS satellite clocks?

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If in the Ives and Stilwell experiment the frequency of radiation changes due to movement of the source, and in the Pound-Rebka experiment due to changes in gravitational potential, then in the GPS system both of these effects appear simultaneously, which makes their analysis difficult, especially for those who have not yet been able to explain the Ives-Stilwell and Pound-Rebka experiments. And then relativists declare that the GPS system confirms time dilation with great accuracy and would generally be impossible without the theory of relativity.

A high-frequency signal arrives from the GPS satellite orbit to the control center on Earth. This increase in frequency is partially offset by the decrease in frequency resulting from the speed of the satellite. A correction is introduced into the on-board clocks of GPS satellites, which relativists explain by the fact that at an altitude of **20,184** km and at a speed of **3.874** km/sec, the atomic clock without correction runs **38** microseconds per day faster than on Earth [1].

Why do these effects occur and are they relativistic? It is shown below that the effects are explained from a purely classical point of view without relativistic "slowdowns" of time.

Just a few days after the launch of the world's first Soviet satellite, American scientists noticed that they could determine the location of the satellite based on the Doppler shift of its radio signals, and by the mid-60s they had created the simplest navigation system of 6 satellites rotating in polar orbits, which allowed nuclear submarines use the Doppler effect to determine their exact location within a few minutes.

In **1973**, the Pentagon decided to create a "military navigation satellite system" Navstar-GPS, which is now called the Global Positioning System (GPS). The system became fully operational in **1993**, and by **1995** the **24**th GPS satellite was launched.

There are currently 31 active GPS satellites (24 basic and 7 additional) at an altitude of approximately **12,500** miles (**20,117** km) above the Earth's surface. Since **201**1, GPS has operated as a constellation of **27** basic and **4** additional satellites. The satellites orbit the Earth with a period of 12 hours and **continuously** send navigation signals to Earth, by which receivers on Earth determine their location by calculating the time difference between the time the signal was received and the time when it was sent by the satellite.

High positioning accuracy in the GPS system was made possible due to a number of factors, but the main ones are the accuracy and stability of orbital parameters, the accuracy and stability of clocks, and the method of measuring distances using a source clock and a receiver clock with the ability to inform the receiver of the satellite coordinates and the time the signal was sent.

GPS satellite orbit control accuracy

Five U.S. Space Force stations track the satellites' flight paths and provide control and fine adjustments to the satellites' orbits and clocks. Stations on Earth carefully monitor the orbit of each satellite. The accuracy of the orbits can be judged by the fact that the positioning accuracy of the GPS system up to several centimeters directly depends on the distances measured from the orbits.

Accuracy and stability of **atomic clocks**

Each satellite has several highly accurate atomic clocks. Control centers **simultaneously** synchronize the atomic clocks of all satellites and the clocks of all receivers on Earth several times a day with an accuracy of three nanoseconds. Each satellite continuously transmits its orbital position and the exact time in this position **to all receivers** on Earth, that is, it synchronizes the receiver's clock with its own clock.

Positioning accuracy depends on the receiver: a method called differential GPS or additional (for military) encrypted signals can determine the position with an accuracy of better than 1 centimeter (less than half an inch).

Method of measuring distances

The distance S from the GPS satellite to the receiver on Earth is determined by multiplying the speed of light C = **299,792,458** m/sec by the time Δt during which light travels this distance:

Метод измерения расстояний

Расстояние S от спутника GPS до приёмника на Земле определяется умножением скорости света **C=299 792 458** м/сек на время Δt, за которое свет проходит это расстояние:

$$S = C \Delta t \quad , \text{ where } \quad \Delta t = tr - ts \quad \text{and}$$

tr - the time according to the receiver clock when the signal arrives at the receiver,

ts - the time according to the satellite clock at the moment the signal is emitted.

This method of determining distances contradicts Einstein's principle of clock synchronization, since it uses **two clock**s and the speed of light in one direction. But the GPS system works great. And it works even if no “relativistic” correction is introduced at all. It works accurately not because the correction was introduced or not, but because **Bradford Parkinson** and the group he led used a method of measuring distances with **simultaneous synchronization** of the clocks of all satellites and had entered into the satellite signal a message to the receiver about the position of the satellite and the moment the signal was sent.

Already in the first positioning systems (before the launch of the first **GPS** satellite in **1977**), it was found that a correction had to be introduced into the clocks, but the reason for its introduction still remains unclear for many - the elimination of supposed relativistic effects or a significant simplification of the positioning problem. The correction was introduced into the clocks of the first GOS satellite.

Let's take a closer look at the method used in GPS to control satellite signals and the question of why a correction was introduced into the atomic clocks of satellites.

The positions of orbits and satellites are known with the highest accuracy. By signals from control centers, the clocks of all satellites are **simultaneously** synchronized with each other with an accuracy of several nanoseconds. With such precision, the clock remains synchronous until the next adjustment signal and **simultaneously** sends a signal to all receivers, additionally reporting its exact position in orbit and the time the signal was sent. Is it important in this case at what speed the satellite's atomic clock runs and whether or not some correction for the speed is introduced? Obviously not.

Let's assume that no correction has been introduced into the satellite's clock and, according to relativists, it goes a little faster than the receiver's clock and advances by **38.636** microseconds in **24** hours, which should lead to a positioning error of **11.4** km. One can reason this way if one does not know that even before the signal was emitted, the receiver received a message from the satellite about what time its clock was showing (that is, the satellite, before emission, additionally synchronized the receiver's clock with its own and the receiver's clock began to show the same time as and the satellite's clock), and at the moment the pulse was emitted, he reported the time the pulse was sent (that is, he confirmed his time). Based on the time difference, the receiver determines the distance to the satellite.

What changes when an amendment is introduced? Nothing, since the satellite also continuously informs the receiver about its time, synchronizing the receiver's clock before sending the signal, at the moment of emission it also reports its time and therefore the receiver will receive the same time difference as in the absence of correction. Relativists, of course, can say that during the time of **0.0667** seconds, while the pulse travels from the satellite to the receiver, due to the difference in clock speeds, a time difference can arise... Let them calculate this difference, but without us.

And we would be interested to know how they explain the fact that control centers correct satellite clocks after 8 or more hours. But in 8 hours, while there is no adjustment, the clock will fall by **12** microseconds and an error of more than 3 km should occur. But it doesn't arise. What, do the constant discussions of relativists about 38 microseconds indicate their ignorance or is there something else here?

As shown above, the correction for the speed of the atomic clocks of GPS satellites has nothing to do with the fantasies of relativists about “slowing down” and “accelerating” time and is introduced to simplify the operation of the system.

Tuned to a frequency of **10 230** MHz, the atomic clocks in GPS orbit run at the same frequency of **10 230** MHz and emit signals at this frequency. But due to the influence of the speed of movement and elevation, the two effectssimultaneously arise - the transverse Doppler effect and the effect of gravitational displacement - and instead of a frequency of **10 230** MHz, a frequency of **10,230,000,004,660** Hz comes to the receiver on Earth, whicht is increased by **4.6**6 Hz.

In order to coordinate numerous receivers on Earth with the frequency of signals coming from satellites, it was necessary to tune all receivers to a frequency of 10 230 000 004.660 Hz **or** reduce the clock frequency of GPS satellites so that a signal with a frequency of 10,230 MHz would come at Earth.

The second option was chosen because it is much simpler, and that is the only reason why a correction of 4.664 7 Hz was introduced into the satellite clocks. All GPS satellite clocks emit signals at a frequency of **10,229,999,995.33** Hz, downscaled by **4.66** Hz. At this frequency, signals emitted by satellites come to Earth at a frequency of **10,230** MHz. But the frequency changes not because of the “decelerations” and “accelerations” of time invented by Lorentz and Einstein, which change the speed of atomic clock, but due to the fact that immediately after radiation, in accordance with the transverse Doppler effect, photons reduce the frequency by **0.854** Hz and, when moving in a gravitational field, increase the frequency by **5.5189** Hz, resulting in a frequency of **10,229,999,995.33** Hz increases by **4, 664 77** Hz and the receiver on Earth sees a frequency of **10 230 000 000** Hz [2]. The correction of **4.66** Hz has nothing to do with the fairy tales of the theory of relativity about the "acceleration" or "deceleration" of time.

Referenses

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