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VARIATIONS IN THE SPEED OF LIGHT AS A POSSIBLE SOURCE OF SPACE NAVIGATION, RADAR AND LASER LOCATION ERRORS

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Abstract: Analysis of systematic errors in astronavigation, radiolocation and laser ranging of astronomical objects and spacecraft is carried out. In particular, errors of radiodetermination of Venus, Pioneer effect, Flyby anomaly and irregularities of the Moon and Earth rotation detected by laser ranging are studied. The ballistic theory is analyzed according to which these errors are caused by unaccounted variations of radio signal and light velocities which, in their turn, are caused by influence of source velocity. It is shown that this classical theory predicts the correct value and sign of the error in all the studied cases and consideration of variability of light velocity as well as consideration of reemission of the light by the medium allows to relevantly decrease the value of systematical errors.

Key words: planetary radar, astronavigation, speed of light, ballistic theory, Lunar laser ranging, GPS, GLONASS.

Dedicated to the memory of V.P. Seleznyov, the first cosmonavigator

Introduction

Astronomical measurements of the positions of planets and spacecraft are reduced to two main methods - to the measurement of their geocentric angles φ and θ (azimuth and altitude, or direct ascent and inclination) and distances *r,* that is, in fact - to the measurement of their positions in the spherical *(r,* θ, φ) system of coordinates. If classical astronomical measurements based on telescopes and radio telescopes are based on the measurement of angular coordinates, measurements based on laser location and radar allow to determine distances, as well as radiation speeds of movement - on the Doppler shift of frequency of the reflected signal. As the history of astronomy and radio astronomy has shown, these methods of measuring coordinates, on the one hand, complement each other, and on the other, often contradict each other and yield inconsistent results, especially if measurements are carried out along long areas of orbit, and additionally take into account the laws of celestial mechanics.

As a rule, in the case of such contradictions, long-range measurements are preferred, because of their great accuracy, reaching a few centimeters at the location of the Moon, and at the radar of the inner planets - several kilometers. This was in order more than the accuracy of angular optical measurements and their corresponding linear errors. The high accuracy of the measurement of distances $r = c\tau/2$ is due to the huge accuracy of the measurement of the latency time of the reflected signal (flying at a speed of *c),* reaching up to 10^{-14} with femtosecond laser pulses. For laser and radar data, high accuracy is confirmed by a small scattering of distance values measured during one location session or in different sessions in the same areas of orbit. However, such high accuracy indicates only a small random error, but does not exclude the existence of large permanent systematic errors of laser and radar, which can be identified only by comparing their data with the data of other methods.

Indeed, as we will show further, the results of long-term measurements in some cases are at odds with the theoretical values of distances and with the data of visual angle measurements, and by a value higher than the error of the latter. This suggests the presence of systematic errors of radio and laser location. Since the accuracy of the signal delay time measurement is reliably controlled, errors can only be associated with inaccuracies in the accepted light speed value *c* [5], the reasons for which we will consider further.

2. Errors and anomalies of radar of planets

Over the past half century, sessions of space radar and laser location, conducted in the USSR, Russia and the United States, have revealed a number of anomalies in the form of exceeding possible errors of systematic deviations of measured velocities and distances of spacecraft bodies and spacecraft from the calculations. Due to the increasing accuracy of computer-based methods and procedures, more and more such anomalies have been detected in recent years.

Space Navigation Pioneer V.P. Seleznev, the American physicist B. Wallace and a number of astronomers named as a possible source of such errors - deviations of the speed of signals from the nominal value of light *c,* prescribed by the special theory of relativity (STO). just as the speed of a moving gun is added to the speed of the projectile it fired (hence the name of the theory). that the speed of the source only affects the direction of the speed of the light emitted by it, but does not affect its magnitude. That is, in the relativity theory there is a paradoxical situation when the speed of light is added to the transverse component of the speed of the source (changing direction of light), but not added longlived, which would noticeably change the speed of light in size.

However, the dependence of the magnitude of light velocity on the speed of the source does not contradict the data of the experiments [-15-17q] and is indirectly confirmed by the data of laboratory experiments [-18, 19] and astronomical observations, explaining a number of cosmic anomalies [-15, 20-23]. De Sitter's analysis of the observations of double stars, which for a century was cited as a contradiction of ballistic theory, as it turned out, has no evidentiary power. Astronomers P. Gutnick and E. Freundlich showed exactly a century ago, in 1913, in response to De Sitter's criticism that distortions of visible stellar movements influenced by the speed of the stars on the speed of the light they emitted are actually observed in the form of the Barr effect, [15, 27, 28]. In addition, as revealed by the American physicist J. Fox, on the path of light to Earth on the the theorem of reradiation *(extinction)* of Ewald-Oseen, the original light of the star is gradually extinguished by clouds of interstellar gas and re-emitted by them at a speed *of c* relative to clouds. For light with a wavelength of the wavelength, at the concentration of *atoms N* ^{3} cm and the refraction of *n* interstellar gas, Fox estimated the characteristic length of reradiation

$$l = \frac{\lambda}{2\pi(n-1)} \tag{1}$$

Accordingly, distortions of the visible motion of the stars caused by the influence of the source speed on the speed of light and proportional paths *l,* at which the speed of light differs from *c,* will be much less than expected by De Sitter. Re-radiation, as Fox has shown, should be taken into account in a number of other terrestrial and space experiments, where the material re-radiation of light by the environment.

As early as the 1960s. in the first successful radar sessions of Venus, carried out by V.A. Kotelnikov's group in the USSR and I. Shapiro's group in the United States, they revealed systematic discrepancies (hundreds of kilometers higher than possible errors) between the measured radar positions of the planet and its precalculated positions - ephemeris calculated from the data of astronomy. As B. Wallace has shown, the discrepancies will decrease at times, given the ballistic dependence of the speed of light on the speed of the source - radar on Earth, moving at a speed *v* due to the axial rotation of the Earth, rotation of the Earth-Moon system and circulation around the Sun. From the message, the radio speed *v* changes its speed $c + v$ and the time of the signal movement, which is the distance *of the Earth-Venus* (Figure 1). As a result, the calculated distance *c* (or $c\tau/2$, taking into account the time of movement of the reflected beam), found from the constant speed of light *c*, differs from the true distance $(c + v)\tau$.

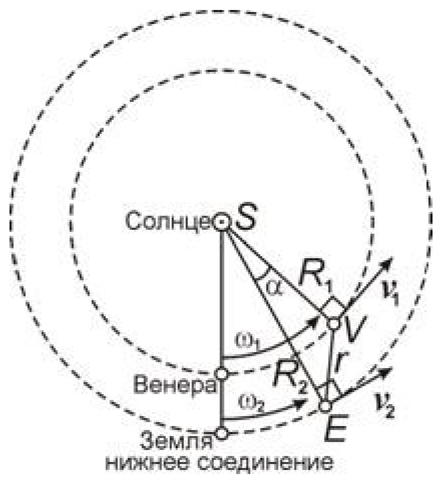

Fig. 1. The Earth's motion pattern and Venus near the bottom connection, as the circular orbits approach.

The effect of the Earth's axial rotation reporting its circumference speed (~500 m/s) to the radar was manifested, for example, in the fact that the radar stations of the USSR and the USA located in opposite points of the Earth and synchronously measuring distances to Venus were receiving different values. Moreover, as noted by B. Wallace [11, 12], A.K. Shurupov [35], S.A. Basilevsky and V.I. Sekerin [36], systematically more the value of distances at stations was received, which, during the daytime rotation at the time of measurement, were distancing themselves from Venus and the ballistic theory reduced the speed of the radio signal, leading to an abundance of time-lag and calculated distance. And for stations close to Venus, the distances were systematically less, which could be attributed to an increase in the speed of the radio signal and a reduction in the time of delay.

One of the purposes of Venus radar was to clarify the astronomical unit (a.u.) - the radius of the Earth's orbit R_2 (the average distance of the Earth from the Sun). Measuring the radar distance r Earth-Venus, from the angles in the triangle SVE (Sun-Venus-Earth) calculated the distance R_2 Earth-Sun proportional to r. But, contrary to the name, the calculation of a.u. has regularly changed [5] with periods equal to days, month and synodic year Venus, with which the relative speed of the Earth changes, causing deviations in the calculation distances Venus and in R_2 [11, 12]. The radar-measured value of a.u. was different from the value measured by visual methods of astronomy. Moreover, the difference exceeded the error of these methods, which was not explained [5, 32], although it was expected on the ballistic theory.

Venus also reports its v_r speed to the reflected signal when approaching, and it reaches the Earth in less time. After the maximum approximation to the Earth in the lower connection, Venus is removed, the signal speed becomes lower than c, and it spends more time, the excess r. From that point to the connection, the calculated values of the EarthVenus distance $r' = c\tau/2$ and the astronomical unit were lower than the real ones, and after the connection - higher (Figure 2) [5].

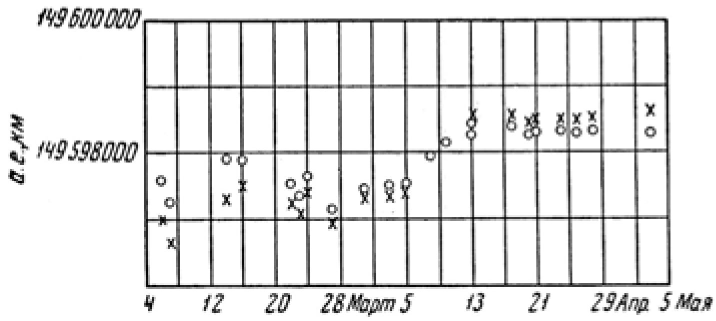

Fig. 2. The values of the astronomical unit depending on the date of the radar session [5, p. 190] (lower formation - April 11, 1961).

If you consider that the signal to Venus only goes at a speed with respect to the Earth, the path r over the time of $\tau_1 = r/c$, and the signal reflected at the radial (radial) speed of Venus v_r will return at the speed $c' = c - v_r$ over the time of $\tau_2 = r/c'$, the total delay is $\tau = \tau_1 + \tau_2 = r/c + r/c'$. Found from the rated speed with distance $r' = c\tau/2 \approx r + rv_r/2c$ will exceed the real r with $\Delta r = rv_r/2c$. From the triangle SVE in the approximation of the circular orbits of planets (Figure 1) the radial speed Venus $v_r = (\omega_1 - \omega_2)R_1R_2 \cdot \sin(\alpha)/r$ where, $\omega_1 = 3.2 \cdot 10^{-7}$ rad/s, $\omega_2 = 2 \cdot 10^{-7}$ rad/s - angular heliocentric speeds, respectively, Venus and Earth, $R_1 = 108 \cdot 10^9$ m, $R_2 = 150 \cdot 10^9$ m - their radius bit, $\alpha = (\omega_1 - \omega_2)t$ - the heliocentric angle of the VSE between them, and t is expressed in the days which have expired since the lower connection. Then the systematic distance deviation, expressed in kilometers, will be found as

$$\Delta r = r' - r = (\omega_1 - \omega_2)R_1R_2 \cdot \sin[(\omega_1 - \omega_2)t]/2c \approx 3350 \cdot \sin(0.011t) \text{ km}. \quad (2)$$

The same deviation expressed in light seconds (by delay time) is

$$\Delta\tau = \Delta r/c \approx 0.011 \cdot \sin(0.011t)\ c. \quad (3)$$

In fact, it is precisely these variations of systematic distance-viscous errors, Δr (Figure 3.a) or time $\Delta\tau$ (Figure 3.b), i.e. the differences measured, τ_0, and calculated, τ_c, from the Newcom tables. The introduction of these amendments (2) and (3), taking into account the ballistic principle, reduces the systemic deviation: Only random errors remain, which will be reduced if the Earth's rotation effect is taken into account [11, 12], as well as the interplanetary environment's reradiation. As the distance r and the layer of interplanetary plasma passed rise, the signal re-radiated by the interplanetary plasma restores the speed c, so the deviations stop growing with the departure from the lower compound (Figure 3). The effectiveness of this reradiation can be assessed by comparing *r* with the thickness of the re-emitting layer of plasma $l = \lambda/2\pi(n - 1)$ according to the formula (1), based on the refractive indicator *n* calculated for the given wavelength as measured by the interplanetary placard concentration plasma, gases and dust.

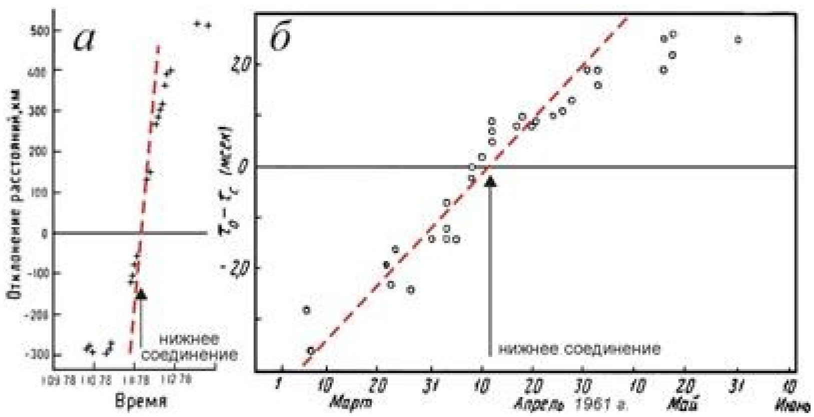

Fig. 3. Venus radar distances deviations from ephemerides (according to Newcom tables) measured in kilometers (a, crosses) [1] and light milliseconds (b, circles) [5, p. 242],compared to the prediction Dependencies (2) and (3) according to Ritz theory (dashed).

Influence of plasma reradiation can, in particular, explain the mismatch ~ 1000 km (going beyond the errors of radar methods) of astronomical unit values measured by different radar stations at different frequencies of 408 - 2388 MHz [37]. Indeed, the refraction of *n* and the reradiation length of *l* differ at different frequencies, and thus the distance within which the speed of the radio signal reflected by moving Venus is different from *c*. And, as noted [37], these differences cannot be written off as dispersion of the interstellar environment, which would always result in less distance measured on short waves than on long waves. In fact, there was "no visible link between the obtained astronomical unit values and frequency" [37]. According to ballistic theory, such a clear link should not be, once the measured amount of an astronomical unit is affected not only by the frequency of the sensing signal (and the length of the transmissions *l*), but also by the sign and the amount of the radiological speed of Venus, and therefore, by the date of the radar sessions, which, like the frequencies, they were reported to different observatories.

Since the systematic differences of the radar data with ephemerides could not be explained, the differences were formally corrected by ephemerid correction, for example by introducing amendments to Dankomb, which "moved" Venus forward in orbit by 290 km, that is, increased the heliocentric longitude of Venus to 0".55 [5]. Even though there were still differences, Venus was replaced by another 270 km, increasing its heliocentric longitude by another 0".52 [38] and building a numerical theory of the planet's movement according to the radar data [1]. However, systematic discrepancies in hundreds of kilometers (corresponding to the errors of the celestial coordinates of Venus ~ 1") of radar data with the tables of Newcoma-Dancomba and visual data were kept all the time [1, 3, 39] and still not explained. Consent between these two types of data, it is noted, is only satisfactory [3].

Although it is believed that significant deviations (~1,000 km) occurred only in the first radar sessions, and during the clarification of its methods the errors decreased by orders, in fact ephemerides were gradually corrected according to radar data. In such iterations, the results of each subsequent radar measurements were less and less different from the ephemerides [33, 40], which suffered one reduction after another. However, the systematic error of measured positions of Venus, in the form of the difference between radar measurements and visual angular measurements, was maintained for decades at the level $\Delta \sim 1'' \sim 5 \cdot 10^{-6}$ rad [3, 40], although astronomical instruments (especially based on interferometry methods) were also improved. To date, their accuracy has significantly increased, reaching hundredths and thousands of parts of a second. Thus, the systematic error $\Delta \sim 1''$ in long series of observations is an order of magnitude greater than the accuracy of the previous astronometric methods (and by orders exceeds the modern accuracy of astrointerferometers and radio telescopes), corresponding at the Venus distance to the systematic displacement of the order $R_2\Delta \sim 750$ km forward in orbit.

These errors were vividly evident in 2004, 2012, when astronomers observed Venus passing through the Sun's disk: The moments of contact between the planet and the Sun disk were in the order of a minute [41, 42] behind the ephemeridic, radar "amendments" [1], which moved Venus forward in orbit hundreds of kilometers. Since during this time t ~ 1 min angle offset of Venus relative to Earth $\alpha = (\omega_1 - \omega_2)t$ and linear - $\alpha R_1 = (\omega_1 - \omega_2)tR_1 \approx 500$ km, it can be assumed that the delay is caused by the erroneous "displacement" of the planet in the orbit forward Based on radar data. This can be verified by more accurate measurements of Venus positions using modern telescopes and ultralong-base radio telescopes (LRDS), as radio radiation from the hot surface of Venus is clearly recorded [43]. Measurement of Venus positions can be done either by measuring the coverage of Venus radio-emitting objects with precisely measured celestial coordinates, directly by the data of radio-interferometers with superlong base, or by triangulation measurements based on the order of the Earth's diameter, repeatedly Radio interferometer networks.

Similar comparative measurements of positions and orbital elements according to the data of long-range, Doppler and angular measurements are interesting for other planets, especially for Mercury and Mars. For them, radar-based orbits and positions also contain significant systematic differences (up to 400 km) with Newcom's analytical theory and ephemerides calculated from visual astronomical observations [3, 44]. For these planets, because of their high orbital eccentricity, we can expect even greater differences and mildness than Venus. Because of variable orbit speed, radar errors cannot be fully corrected by adding a permanent orbit offset. But, of course, the numerical theory of the movement of planets, based on the radar data, is still more consistent with the subsequent radar measurements (containing the same systematic errors) than with the data of Newcom's analytical theory, built on visual observations of planets [45].

Radar errors can also be fatal when calculating asteroids crossing Earth's orbit and close to the planet, especially in light of the unpredicted fall of the Chelyabinsk (Chebarkul) meteorite. Therefore, in order to prevent asteroid danger in a timely manner, the accuracy of radar should be thoroughly tested, its methods improved, the range and sensitivity of space radars increased.

3. Spacecraft radar errors

The spurious "shift" of Venus in orbit for the first time drew attention to the space navigator, who trained the first units of astronauts, - Prof. V.P. Seleznev [8], employee of S.P. Korolyov and author of the monograph "Navigation Devices" (M: Oborongiz, 1961), who created navigation systems of the first spacecraft. Seleznyov showed that without the consideration of ballistic theory "on the basis of scientific information about light, astronavigation is in principle impossible" [46, p. 308]. He also noted the importance of ballistic theory in navigation of AMS and spacecraft, a number of crashes of which, say, at the devices "Fobos-I" and "Fobos-II", caused by radar errors [8-10, 46].

It is possible that the accidents of a number of other vehicles sent to Venus and Mars in different years are caused by systematic errors in measuring the positions of the apparatus and planets on the basis of radar data. Obviously, the radar measurements of orbits elements are more accurate when it comes to measuring the radius of orbits of planets (their large half-axes). It is these characteristics that play a major role in the calculations of the trajectories of the devices. Therefore, without radar measurements inaccuracy in the meaning of the astronomical unit and radius orbits of other planets would lead to significant failures of the devices past the planets, reaching several diameters of a planet like Venus or Mars [1, 37]. A less critical parameter is the position of planets in orbit, for which astronomical angular measurements are more suitable. Since the AMS transition orbit trajectory (for example, in the orbit of Goman) is almost tangential to the orbit of the planet, inaccuracies in the orbit determination will only affect the moment when the spacecraft passes near the planet, and the distance of the final rapprochement will hardly change. However, in this case, errors in measuring the position of the apparatus and the planet can lead to accidents and missteps, with which V.P. Seleznev and connected a number of AMS accidents sent to Venus and Mars.

Let's look at the "Pioneers" effect [47, 48] - an anomaly, revealed among others by the JPL NASA. The speed of the Pioneer-10 and Pioneer-11, measured by radars (according to the Doppler signal frequency shift from the AMS), differed from the calculation [7]. The measured acceleration of the "Pioneers" in the field of gravity of the solar mass M exceeded the calculated acceleration $a' = GM/r^2$ by the value $\Delta a_o = (8.74 \pm 1.33)\cdot 10^{-10}$ m/s^2 (at the distance r Uranus [48]). If the "Pioneers", flying from the Sun and the Earth at a speed of $\approx$ 10 km/s, emitted a signal at the speed $c - v$, increasing its delay τ, the nominal speed of the signal c determined that the speed and acceleration of the AMS are measured at the distance $r' = c\tau \approx r + rv/c$ instead of the true $r = (c - v)\tau$, where the gravity of the Sun and the acceleration $a = GM/r^2$ is higher than the calculated $a' = GM/r'^2$ by

$$\Delta a_c = a - a' \approx 2av/c = 2vGM/cr^2. \tag{4}$$

At the Uranus distance $r \approx 3\cdot 10^{12}$ m at $v \approx 10$ km/s this will be a calculated value of $\approx \Delta a_c$ $9.9\cdot 10^{-10}$ m/s^2, close to the measured $\Delta a_o \approx 9\cdot 10^{-10}$ m/s^2 [48]. Similar anomalies were found in AMS Ulysses [49] and Cassini, which at Saturn's distance ($r \approx 1.5\cdot 10^{12}$ m) measured excess acceleration $\Delta a_o \approx 3\cdot 10^{-9}$ m/s^2 [50] is close to the reference $\Delta a_c = 2vGM/cr^2 \approx 4\cdot 10^{-9}$ m/s^2.

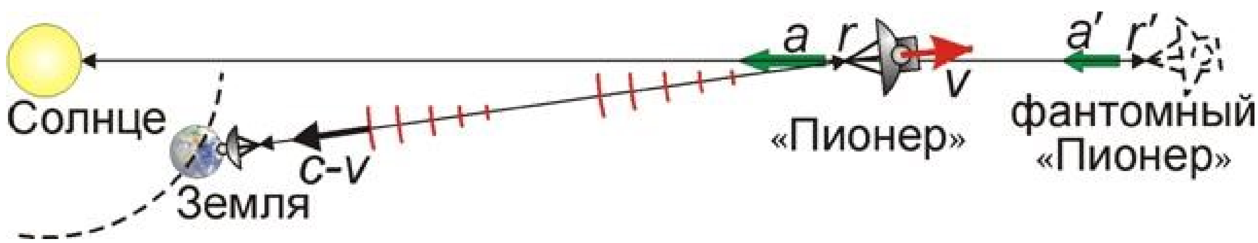

Fig. Pioneer radar map (top)

It should be noted that the main hypothesis, which explains the abnormal acceleration of "Pioneers" by the radiation forces from the uneven heating of the hull by an isotope source [51], is dubious, because an abnormal acceleration of the characteristic size and direction was found in a number of other AMS having fundamentally different designs and power sources. Therefore, it is unlikely that the same force directed towards the Sun would appear in all cases. In addition, the Pioneer's housing is covered with a reflecting film with gold coating, which emits poorly heat for thermal insulation purposes. Reflecting and reradiation by film, whose surface is infinitely complex, is a task beyond the control of even numerical modeling. From the placement of the film on the side of the apparatus facing from the Sun, the radiation of the heat there may not be higher, but lower, than from the side of the antenna (facing the Sun and the Earth), where the radiation force is reverse. That is, radiation forces are not only lower than calculated in [51], but can even have a reverse direction. The agreement of the amount of radiation acceleration with the measured is conditioned by the choice of coefficients characterizing the connection between heating and radiative forces [51].

The low radiative strength also follows from the fact that the uneven heating of the Pioneer's case (demonstrating the shift of the area of maximum heating by $h \sim 1$ m from the axis of the apparatus [51]), creating radiation force F and acceleration $\Delta a_o = F/m \sim 10^{-9}$ m/s^2, would also create a moment of force $M = Fh$ (Figure 5), which, within a twenty-year period of t unguided flight, would have rejected the pione axis and its hard-connected parabolic antennas to the angle α, excluding the exchange of signals with the Earth. Pioneers do not have any reactive direction stabilization systems. The direction of the axis of the apparatus shall be stabilized solely by rotation with an angular speed, $\omega = 4.8$ rpm $\approx$ 0.5 rad/s, and pulse moment, $I\omega \sim md^2\omega/8 \sim mh^2\omega$ along the axis of the apparatus, at which the moment of inertia of the disk diameter $d = 2.7$ m. Therefore, a constant moment M, transverse to this axis, would inform the device of the transverse moment of the Mt pulse and would unfold the axis of the apparatus at angle $\alpha = \mathrm{arctg}(Mt/I\omega) \sim \mathrm{arctg}(\Delta a_o t/\omega h) \sim$ 50°, completely disconnected. At the operating frequency of 2292 MHz ($\lambda = 0.13$ m) and the antenna diameter $d = 2.7$ m, the main torch of its directional pattern is much narrower: $\varphi_a \approx \lambda/d = 0.048$ rad $\approx 3°$. If the antenna was originally directed to the Earth, when the devices were rotated to the angle $\mathrm{arctg}(\Delta a_o t_0/\omega h) \sim \varphi_a/2$ the connection would have been lost already after the time $t_0 \sim \omega h\cdot \mathrm{tg}(\varphi_a/2)/\Delta a_o \approx 0.4$ years of their free flight, - long before the orbit of Uranus crossed. The fact that communications have been maintained for decades, up to the intersection of Pluto's orbit and beyond, shows that the Pioneers' axes remain in space and that no visible radiological or other unaccounted forces exist.

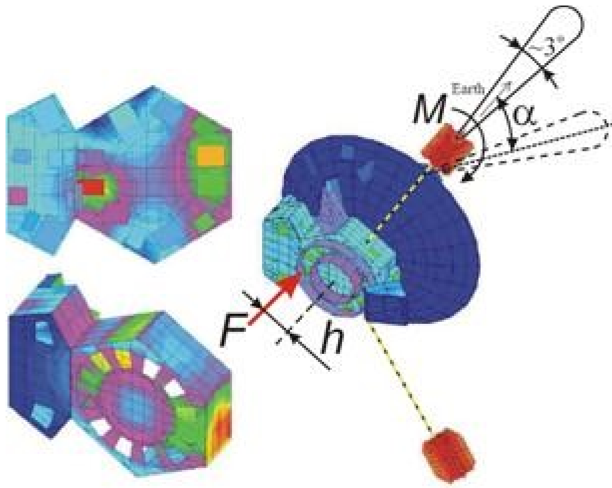

Fig 5. Asymmetrical temperature distribution across the Pioneers [51], creating radiation force F and anomal acceleration Δa_o, would cause the M moment to appear, diverting the AMS antenna away from the Earth.

Flyby anomaly [48, 49] is also open, i.e., the failure of expected speeds and measured radars in the AMS flying past the planets along the hyperbolic trajectory. For example, at AMS "Galileo", "NEAR", "Rosetta" after passing the Earth, the growth of speed by a number of mm/s was detected, contrary to the law of energy conservation. The probable cause of errors is the application of the doppler effect in the measurements of the speed of relativist formula devices

$$f' = f\frac{\sqrt{1 - v^2/c^2}}{1 \pm v/c}, \tag{5}$$

by which the frequency of f is increased to $f_1 \approx f(1 + v/c + v^2/2c^2)$ when converging, and when removing - reduced to $f_2 \approx f(1 - v/c + v^2/2c^2)$. In classical physics

$$f_1 = f(1 + V/c) \text{ and } f_2 = f(1 - V/c), \tag{6}$$

and in space, these symmetrical frequency shifts are measured: $f_1 - f = f - f_2$. That is, based on the classical formulas, the speed of V devices is maintained. However, calculating the speed according to the STOs, get, equating the measured frequencies (6) to the relativist frequency (5), that when approximation $v \approx V - V^2/2c$, and at distances $v \approx V + V^2/2c$, hence - false conclusion speed increments of $\Delta v \approx V^2/c$. At the AMS speed $V \sim 10^3$ m/s this will create an illusion of increase of speed $\Delta v \sim 1$–10 mm/s.

Also in the satellites of the Moon, Earth and other planets, the anomalies of motion can be connected not only with the anomalies of the gravitational field (masks), but also with systematic errors of radar from failure to account for variations of the speed of light and application of formulas of the STO. Perhaps because of this more High precision is given to measurements of gravitational anomalies using two satellites (e.g. Abb and Flow in NASA Grail mission) flying in orbit one after the other and by radar and measurement of Doppler offsets detecting variations of relativity speed and distance between satellites, when entering anomaly zones. Similarly, the Kaguya Japanese probe, which flies in a low orbit around the Moon, reveals gravitational anomalies by radar from the Okin relay satellite, which flies in a higher orbit. On the one hand, it allows for communication with the Earth and measurements when one of the satellites enters the radiotherapy of the Moon, and on the other, allows for relative measurements with higher accuracy than in measuring the absolute distances of satellites to the Earth. This is due not only to the increase in errors as the distance increases and the variable delay of the radio signal in the Earth's ionosphere, but also to the fact that the relative speed of satellites, especially those moving one orbit at a time, is small (compared to the speed of the Earth). So, its effect on signal speed and distance measurement errors is negligible.

The networks of GPS and GLONASS satellites [52], using the method of radar from ground tracking stations and groups of artificial satellites, also show errors. The navigation module in the mobile device "catches" radio signals sent by satellites and containing information on the position of each satellite (monitored by stations) and the time of the signal radiation (at atomic hours on the satellite). Subtracting this time from the time of reception of the signal, the mobile receiver, on the time of motion of the radio pulse calculates the distance $r = c\tau$ to the satellite. The distance of r_1, r_2, r_3, r_4 to three or four satellites and their coordinates of the microcomputer calculates the position of the receiver on the earth's surface.

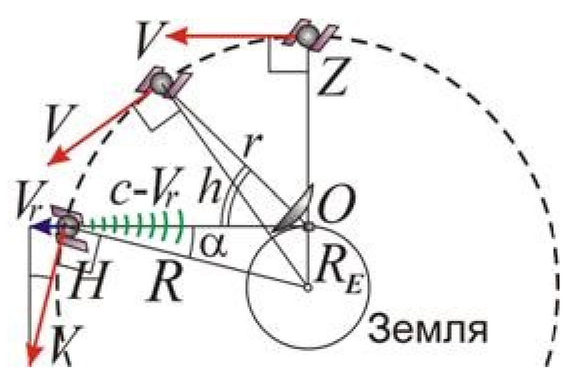

Fig. 6. The pattern of movement and radar of Earth's navigational satellites.

It is believed that GPS and GLONASS confirm the formula $r = c\tau$ and the constant speed from the signals from satellites [53]. Let's check to see if this conclusion is valid. Satellites place an R radius of about 26,000 km into orbit. The speed of the satellites $V \approx 4$

km/s will reduce their signal speed to $c' = c - V_r$, where V_r is the satellite's beam speed for receiver O. Then the distance adjustment $\Delta = rV_r/c$, where for the satellite in the zenith Z the speed $V_r = 0$, but it increases when the height of h satellite is reduced above the horizon: $V_r = V \cdot \sin\alpha \cdot \cos h$, where $\sin\alpha = R_E/R \approx 0.25$, $R_E \approx 6400$ km is the radius of the Earth (Figure 6). Then the maximum distance error $\Delta = rV_r/c = 67$ m near the satellite near the H horizon. Since the receiver usually catches signals from satellites from $h > 10° - 15°$ and is at an angle of $\theta > 0°$ to the plane of orbit of the satellite, $V_r = V \cdot \sin\alpha \cdot \cos h \cdot \cos\theta$, which, taking into account $\cos h \leq 1$, $\cos\theta \leq 1$, gives the medium error

$$\Delta = \frac{rV}{c} \sin\alpha \cdot \cos h \cdot \cos\theta \sim 20 \text{ м.} \tag{7}$$

In fact, it's a mistake in the distance of one satellite, and the coordinates are based on 6-10 satellites. All of them give errors of different signs and values, randomly summed in different directions, and their mutual compensation, if averaged, further reduces the error. And this is a general error in height and horizontal, and the error in measuring projection on the globe is even lower. As a result, the adjustment to the horizontal coordinates of the receiver, made by the variation of the speed of light, is about 5 m, which is comparable to the observed errors. Moreover, in accordance with the formula (7), the actual errors observed Δ are almost zero for the satellites in the zenith ($h = 90°$), and grow at the decrease of their h heights, reaching the maximum when the satellite is visible near the horizon. Usually this is explained by the increase of the atmospheric layer and ionosphere altering the speed of the radio signal. However, a comparison of distances measured by twofrequency radio signals (for which the speed by dispersion in the ionosphere is slightly different) usually allows for a near-complete elimination of errors related to refraction and dispersion of the ionosphere. Therefore, the order of errors and their dependence on the satellite height may indirectly indicate the influence of the satellite speed on the speed of the radios emitted by it.

These errors are reduced by applying corrective procedures, including differential methods that are tied to base stations. Systematic errors in measuring the absolute distance of r_1 from satellite to mobile receiver and r_2 to the nearby base station (with known coordinates) disappear when the relative distance and position of the receiver are determined as differences ($r_1 - r_2$), taking into account the satellite's altitude above the horizon .

In addition, one error compensates another by adjusting the ephemerides of satellites, "shifting" them forward in orbit by hundreds of meters (as in the case of Venus, nominally shifted by hundreds of kilometers). Thus, if the coordinates and ephemerides of the satellite are calculated according to the time of propagation of its signals to base stations with known coordinates, then from a constant speed of the signal the position of the satellite is shifted from the real, which exactly compensates the error of measuring distances to mobile receivers. Probably, under such conditions and consider that GPS does not contradict STO [53]. Therefore, it should be independently measured by different methods to monitor the position of satellites: visual (telescopes); laser location (by time of light movement to and from the satellite); by radar (from ground station to satellite or from satellite to station), and by radio interferometers with a very long base [54]. Then, if the speed of the source affects the speed of light, these methods will produce different results.

Geosynchronous satellites (sometimes used as auxiliary in navigation systems) are particularly useful for visual analysis, and their position in the skyscraper is virtually unchanged, making it possible to measure their position very accurately. Comparison of these provisions with radar and laser location data, as well as comparison of the measured distance with the theoretical altitude of the geostationary orbit (accurately calculated for an orbital period equal to days), will reveal the slightest traces of the impact of the satellite's orbital speed on the speed of light. R. Hatch [60], pioneer of GPS system development, head of NavCom company and Institute of Space Navigation Systems (ION), has repeatedly stated about the errors in the GPS system and contradictions of its data - relativity theory.

Not only navigation satellites and orbital stations can be used to check the impact of the source speed on the speed of light, but also any other satellites and orbital stations, which usually carry corner reflectors and radio transponders. Comparison of distances and positions of the devices, simultaneously measured by different methods, can become a simple and reliable criterion of verification of ballistic theory and stability of light speed. It is also possible to use the capabilities of Condor-type vehicles (Cosmos-2487), whose orbit is closely monitored and which accurately measures the coordinates of ground objects. It should be noted that also in the case of "firing" from satellites by laser beam against ground control targets it is necessary to take into account the ballistic principle: Without this, the beam is always a few meters forward due to the effect of the aberration (i.e., the addition of the vector of the satellite's orbital speed to the vector of the speed of its light beam).

So, testing ballistic theory in space is extremely urgent, because radar errors from unaccounted variations in light speed can reduce the accuracy of space programs and lead to accidents of spaceships, as well as simple ships and cars with GPS. However, the consistency of light speed in space has not yet been explicitly verified with satellites, missiles and radar, although the issue of such verification has been raised on numerous occasions. Moreover, when this issue was raised at the NASA conference in the USA in 1961, such an inspection was considered unnecessary [29], although in the same year the inaccuracies in the speed of light were revealed at the radar of Venus [5, 11, 12].

The American physicist B. Wallace linked a similar freeze on official research and information on the subject (in the form of the cessation of radar publications in the US in the 1960's. [3]) - with the deployment of the program "Star Wars" (one of which was the GPS system), where the influence of the speed of the source on the speed of light could be strategically important information [13, 36]. Something similar happened during the Manhattan Project, when the discontinuation of publications in 1940, according to dividing reactions in American magazines, signaled the beginning of secret work in this field, which Soviet physicists correctly interpreted to begin timely development of the motherland's nuclear shield.

4. Laser location errors

Inaccuracies have also been discovered at the Laser Lunar Location (LLL) and artificial satellites, with corner reflectors installed on their surface [55]. At the laser source speed of order $v_r \approx 460$ m/s (rotation speed on the Earth's equator), the light will go the distance of $r \approx 3.84 \cdot 10^8$ m to the Moon faster at time $\Delta t = r/c - r/(c + v_r) = rv_r/c^2 \approx 2 \cdot 10^{-6}$ s, which corresponds to the difference of 600 m, easily measured laser radar (lidar). Taking into account the reflection from the Moon at speed c, the error shall be $\Delta r \approx 300$ m, with the accuracy of the method ~1 cm [2]. Then, in synchronous measurement of the EarthMoon distance by stations from the opposite points of the Earth, when one moves towards the Moon and the other is removed (Figure 7.a), the Ritz ballistic theory will be confirmed if distance differences are identified, $\Delta r \sim 300$ m. For moderate latitudes, the difference is less: $\Delta r \sim 100$ m.

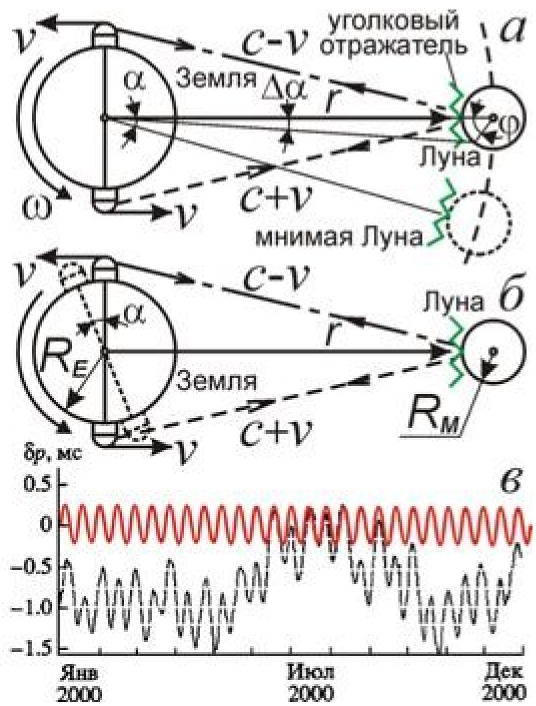

Fig. 7. The scheme of the Moon's laser location. Unaccounted variation in the speed of light creates the illusion of shifting or turning the Moon (a), Earth (b), and variations of the day (c).

A laser location can also be carried by one station measuring the Earth-Moon distance during the night. Then the blades would change with a period of about 100 m/24 h ≈ 4 m/h, and the maximum deviation from the true distance would be about a hundred meters. Indeed, the LLL data and visual data (on the basis of which the Moon ephemerides are calculated) were unblended by hundreds of meters and changed by about 4 m per hour [56, p. 193]. According to NASA employee D. Jezari, having studied the laser location data of the Moon, variations of systematic neo-viscous contradict the constant speed of light, and the ballistic principle significantly reduces these variations and systematic errors [55]. On the contrary, in the STO, the difference between LLL data and ephemerides can be reduced only by correction of the Moon ephemeride based on laser location data. In fact, locational data, as in the case of Venus, are compared to one another, not to observational astronomy.

When you consider the speed of light as constant, you find that the moon is closer to sunset than it is at sunset. This inequality will be regarded as a rotation of the Earth towards an extra angle $\alpha = \Delta r/R_E = 4.5\cdot10^{-5} = 9''.4$ (Figure 7.b) or as an offset of the angle reflector with the Moon at a distance of $r\alpha$ = 17 km forward in orbit (Figure 7.a). From the slope of the lunar orbit to the plane of the earth equator, the distance r to the Moon changes to the value of $\Delta r \sim R_E(1 - \cos 23.5°)$ = 530 km with a period of six months (13.7 days). This changes the angle α to $\Delta\alpha = \alpha\Delta r/r = 0''.013$, which will be seen as the Earth's rolling around the axis with the amplitude $\Delta\alpha/2 = 0''.0066$ and the period $T \approx 14$ days by law

$$\delta\alpha = -0''.0066\cdot\cos(2\pi t/T), \quad (8)$$

where t is measured from the moment the Moon intersects the equatorial plane of the Earth (from the ascending node). This rolling (8) creates an illusion of the oscillation of the Earth's rotation speed ($\omega = 2\pi$ rad/day) by the amount

$$\delta\omega = d(\delta\alpha)/dt = 1.4\cdot10^{-8}\cdot\sin(2\pi/T) \text{ rad/day}, \quad (9)$$

and the duration of the day p - by the value $\delta p = -p\delta\omega/\omega$, as if the day is lengthened, then reduced by 0.2 ms every 14 days by law

$$\delta p = -0.2\cdot\sin(2\pi t/T) \text{ ms}. \quad (10)$$

This theoretical dependence (10) is applied by a solid line on (Figure 7.b). The laser location of the Moon revealed precisely such variations (Figure 7.c, dash): Their period is 14 days, and amplitude - a fraction of milliseconds [57].

So, variations of p can be somewhat illusory, being caused by unaccounted variation in the speed of light. This can be directly verified by regularly measuring the Earth's rotation angle and rotation period by observing the day-to-day motion of the skyscraper of the point space radios, by means of ultralong-base radio-interferometers, which allow to measure variations of the Earth's rotation angle to $0''.0001$. Another method of testing is to measure variations of positions in the sky of geostationary satellites. Or, on the contrary, the measurement by Condor-type satellites of variations of the positions of the Earth's anchors and base stations for which regular Earth pumping at $\Delta\alpha = 0''.013$ would correspond to the periodic offset of the anchor points on the Earth's surface at approximately $\sim R_E\Delta\alpha = 0.4$ m.

Regular variations in the r distance and v_r speed could explain other "variations" of the Earth's and Moon's rotation, identified by the lidars and having characteristic periods of r and v_r oscillations. Thus, the distance of the Moon varies from 350 to 400 thousand km ($\Delta r \sim 50$ thousand km) from the movement in the elliptical orbit. Correspondingly, the angle α (direction to imaginary moon) fluctuates at $\Delta\alpha = \alpha\Delta r/r \sim 1''$. This orbit, synchronized with orbital motion, will be perceived as the "shift" of the Moon in orbit (similar to the "shift" of Venus), changing in its approach-distance. These imaginary shifts cannot be fully reconciled with Kepler's laws, as the shape and inclination of the lunar orbit regularly change [56, p. 63], adding the variation of the Earth-Moon distance $\Delta r \sim 20{,}000$ km and $\Delta\alpha = \alpha\Delta r/r \sim 0''.5$. It may be interpreted as a regular offset of the angle reflector at $\Delta\alpha r \sim 1$ km during the rolling of the Moon (RM radius) to angle $\varphi = \Delta\alpha r/R_M \sim 2'$. Indeed, the lidars have detected regular turns on the Moon at 2', as opposed to visible motions of the Moon (optical libration), explained by real rolling (physical libration).

The "rocking" of the Moon and the Earth through tidal interactions is open at the limit of resolution and in astronomical observations [56, 58]. However, the "swings" detected by the lidars may be partly due to unaccounted variation in light speed. To check the extent to which imaginary oscillations contribute, we can compare the amplitude of the "rolling" of the Moon or the Earth measured by lidars, telescopes, and radio interferometers. If Ritz's ballistics theory is true, their data will vary by amount, according to the laws found. Data from stations of different latitudes will also differ: Near the equator, the fluctuations δp - sine (10), and far from it - neighboring maxims will be produced of different height, which is actually observed (Figure 7.b).

Errors in the lidar-measured positions of the moon also cause errors in the coordinates of the vehicles on it. Perhaps that is why the laser beam, as it becomes sharpened and illuminated on the Moon, is less and less of an area (whose transverse has now been reduced to about 1 km), and has ceased to find the "Moon-1" angle reflector over time due to a false offset of $\Delta\alpha r \sim 1$ km from the measured lily the gift of physical libration, or at $r\alpha \sim 17$ km - from the rotation of the Earth. Indeed, after several successful Lunokhod-1 laserlocation sessions in 1970-1971, it was no longer detectable with a laser radar. For a long time, this was connected with the failure of the corner reflector installed on the "Moon" [2]. However, in 2010, after Lunokhod-1 was visually detected in the Moon surface images made by the lunar orbital probe LRO [59], the coordinates of Lunokhod-1 were updated by visual data and images. The use of these corrected coordinates allowed, after 40 years, to bring the laser beam back exactly to "Lunokhod-1" and to register "lunar rabbit" - reflected signal. And its intensity was several times higher than the intensity of the signal reflected by the "Motorway-2" [59], whose laser location has been regularly maintained up to now and whose coordinates have not been lost due to visual control (measuring the coordinates of the flare point on the Moon)).

This proves that the corner reflector "Lunokhod-1" has been corrected all the time, and the disappearance of the reflected signal was due to the loss of the correct coordinates of the apparatus, due to an error in the definition of coordinates of "Lunokhod-1" on the data of the lidars, compared with which visual data in a number of cases more precisely. It is possible that the gradual "degradation" (reduction of reflectivity) of the other four lunar vehicles [59] is associated with this, because of the gradual loss of the correct coordinates, only the edge of the diffuse atmosphere and the diffraction of the laser beam enters the reflectors, the intense intensity, which is why the intensity of the reflected signal falls. As a result, the reflectors of the other four lunar vehicles, including the Lunokhod-2, are regularly "lost". Only the initial visual measurement of reflector positions (or modern measurements using LRO-type orbital probes) provide the required accuracy of their coordinates.

Indeed, a comparison of the coordinates of all five lunar reflectors ("Lunokhod-1, 2", "Apollo-11, 14, 15"), determined by visual data (LRO images) and laser data The systemical difference in the selenographic latitudes and longitude of $0°.02 \approx 1'$ is shown. This corresponds to the characteristic amplitude of the physical libulation of the Moon (found from these lidars) and corresponds to the difference of coordinates in ~ 1 km. This discrepancy far exceeds the accuracy of the coordinates measured by both methods, and may well be the result of the unaccounted effect of the source speed on the speed of light in the laser location calculations.

5. Conclusions

As shown above, radar and laser location data may contain large systematic errors due to inaccuracy of the accepted speed of light c. As a result, although the adjacent relative positions of bodies or apparatus are measured with high accuracy and good reproducibility, the coordinates of absolute positions and distances from the Earth are measured with a great error exceeding the accuracy of visual angular measurements. By taking into account the effect of the speed of the source on the speed of light and radio signals, it is possible to significantly reduce systematic errors. This effect can be verified by comparing radio- and laser-location data with interferometric telescopes and radio telescopes with a very long base, where the accuracy of the measurement, expressed in a linear measure, is already approaching the accuracy of the long-range measurements, allowing independent and accurate measurements to be made. Thus, while long-range measurements were always preferred, the accuracy and random errors of long-range and angular measurements have now become comparable, allowing for direct comparison of these methods and the detection of systematic errors.

So, the new analysis of the array of radar and laser location data, their comparison with each other, with visual data and with data of the computation positions of planets or AMS will allow to check the consistency of light speed in space and to clarify parameters of axial and orbital rotation of planets and the Moon. And in the current programs, parallel computation of coordinates based on ballistic theory and on the basis of the constant speed of light will allow to compare the accuracy of these calculation procedures and increase the reliability of space navigation. In the future, this will allow to create intelligent navigation systems in which coordinates will be measured in parallel and independently by different methods and compared with the influence of the source speed on the speed of light and taking into account variable thickness and the concentration of the interplanetary environment leading to the re-radiation of the signal and its change in speed.

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