1.2 Pioneer anomaly solution

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Abstract

Application of the universal space-time principle (*g=cd*) explains a Pioneer's anomaly, whose simple solution also proves the principle. Due to its rigid nature, despite the high degree of approximation of calculated values, plotted curves of annual trajectory shortage so as the accumulation of differences between predicted and registered positions of probe are equivalent to those recorded.

1.2.1 A brief description of the anomaly

In 1972 and 1973 NASA launched space probes Pioneer 10 and 11. After completed missions, the monitoring of their movement toward deep space was continued. Several years after their launch, data from probes indicated to the same anomaly. Both Pioneers were unexplainably "slowing down" for some 13,000 kilometres per year. For that amount, their annually registered position was closer than that predicted in calculations of conventional physics. Taking into account their speed of some 40,000 km/h, in the annual trajectory which probes pass, the amount of 13,000 km is not much. To date, however, the value accumulated to an amount greater than the distance between Earth and Moon. The persistence of anomaly indicates that the system that does not predict it is not valid.

To determine Pioneer's distance from Earth, Round Trip Light Time (RTLT) method was used. From one of Deep Space Network (DSN) antennas, the signal with the universal Earth time (UT) was sent to probes. As soon as it is received, the signal is transmitted back to Earth. The time of its reception, is compared to the time of its sending. To the position which Pioneer 10 reached after 28 years of flying (in anomalies solution, the 28 year trajectory data of Pioneer 10 was used), the signal spent some 10 hours travelling at the speed of light and the same time back. Half of the travel time multiplied by a constant speed of light is the result for the distance of probe.
As noted, each year that value was for some 13,000 km, less than expected.

As conventional physics has not explained the observed phenomenon, an anomaly has been listed in the unresolved problems in physics, so for the past thirty years various theories arose from an attempt to explain its nature. Although they claim the contrary, none is found universally valid model that explains it. To detect the anomalies nature, various projects have been proposed including construction of replicas of the probe with sophisticated 21st century instruments and its re-launch in time of similar constellations of planets...

1.2.2 Solution

On its way to the edge of the solar system, relative to the Earth and the Sun, the spacecrafts are advancing through the field towards lower gravity and dilatation.

Newton's acceleration formula counts the mean stretching of orbital space-time, hence the orbital light-second, compared to one seconds before and one second after, i.e. the light second closer and further from the orbiting entity...

An example is provided by a gravity results calculated by the principle of tautological relation of gravity and the speed of light, and acceleration results obtained by Newton's formula for acceleration. Values will be calculated for the solar region of the Earth's orbit.

Dilatation value, thus changing amount of meter and second, for a distance AU (astronomical unit, hence the distance of Earth from the Sun r_o) is calculated by Schwarzschild formula for the gravitational dilation (0.0.1), and it turns out some 0.0000000098739 seconds and as many meters. No consideration of that intuitive scalar principle of symmetric space-time dilation, which always measure the speed of light unchanged, is the crucial error of conventional relativistic physics.

Acceleration value ar_o calculated by Newton's formula (1.2.2.1) for the same distance from the centre of the Sun is some 0.005932 meters (conventionally over second squared);

$$a_{ro} = \frac{GM}{r_0^2} \qquad 1.2.2.1$$

Where G is the gravitational constant and M is the mass of the Sun (calculated over the orbital velocities of its planets and the gravitational constant).

From the equality for the orbital speed (0.0.12), we write the relation for the Earth's orbital dilatation d_o, where v_o stands for its orbital velocity (1.2.2.2);

$$d_o = \frac{v_o^2}{c^2} \qquad 1.2.2.2$$

The resulting amount equals to the amount for which unit is enlarged (0.0000000098739) when using Schwarzschild formula for gravitational dilation. By including obtained dilatation value in formula for gravitation (0.0.8) we get a light second expansion value on that orbital distance from the centre of the Sun, i.e. gravity, which amounts some 2.96012 meters. Thus, this amount is the geometric mean of light speed expansion, in portion of that orbital distance, i.e. the geometric mean between the acceleration of the surface of the Sun and the Earth's orbital acceleration. It therefore refers to the space section of light route trajectory of AU meters and the time portion of AU/c seconds, as opposed to conventionally measured length of 299 792 458 meters in one second time.

From the equality of reciprocal relations between gravities and radiuses (0.0.32), we calculate orbital gravitation at distances light second closer and light second further from the orbiting entity, in other words, the distances r_o-c and r_o+c (1.2.2.3, 1.2.2.4);

$$g_{ro+c} = \frac{gr_o}{r_o + c} \tag{1.2.2.3}$$

$$g_{ro-c} = \frac{gr_o}{r_o - c} \tag{1.2.2.4}$$

The same results are obtained when in the equality (0.0.36), instead of variable n, values r_o+c and r_o-c are included.

The obtained values amount 2.95420 for g_{r+c} and 2.96606 for g_{r-c}. The geometric mean of differences between gravities at r_o-c and r_o and differences between gravities at r_o and r_o+c (1.2.2.5) is equal to the result obtained by valid acceleration equation (0.0.37) and Newton's acceleration formula (1.2.2.1) and amounts 0.005932 meters;

$$a_o = \sqrt{(g_{ro-c} - g)(g - g_{ro+c})} \tag{1.2.2.5}$$

Thus, Newton's acceleration formula calculates the mean relative difference between the light speed expansion one second before and one second after the observed orbital radius.

Since the relationship of gravity, the speed of light and dilation accounts the relative difference in the stretching of space-time between orbital trajectory and its orbital centre, in relation to the space-time orbit from which it is measured, it arises that gravity, unlike the acceleration does not decrease with the square of the distance but linear (0.0.32, 0.0.33, 0.0.35).

For this reason, the registered accumulation of Pioneer probes deceleration increases linearly (Chart 1.2.3.2).

The implication of decreasing gravity and dilatation, with an increase in distance from the Sun and Earth, is contraction of meter and second of Pioneer space-time in relation to the space-time from which we measure, i.e. the Earth's gravitational field in its orbit around the Sun. As at described distance increase, weakens the gravitational field and declines the dilatation, the values of meter and second of Pioneer space-time are reduced. In such referential systems of shorter meters and seconds, according to a valid principle (0.0.8, 0.0.18), the result for speed of light remains unchanged. Since the physics of probes motion in their referential system remains the same, as measured from Earth, where meter and second are longer, in its shorter time Pioneer travels over a shorter distance.

The same scenario occurs with the signal that establishes communication with the probe. At its trajectory toward Pioneer, time and space through which the signal travels are being reduced. For this reason, at any referential system through which the signal passes, it travels at the speed of light measured within that referential system.

Due to the described space-time variation, as measured by Terrestrial space-time units, the signal in its shorter time makes a shorter way. Consequence of described phenomenon is that the signal arrives back to Earth before expected (Figure 1.2.2.1).

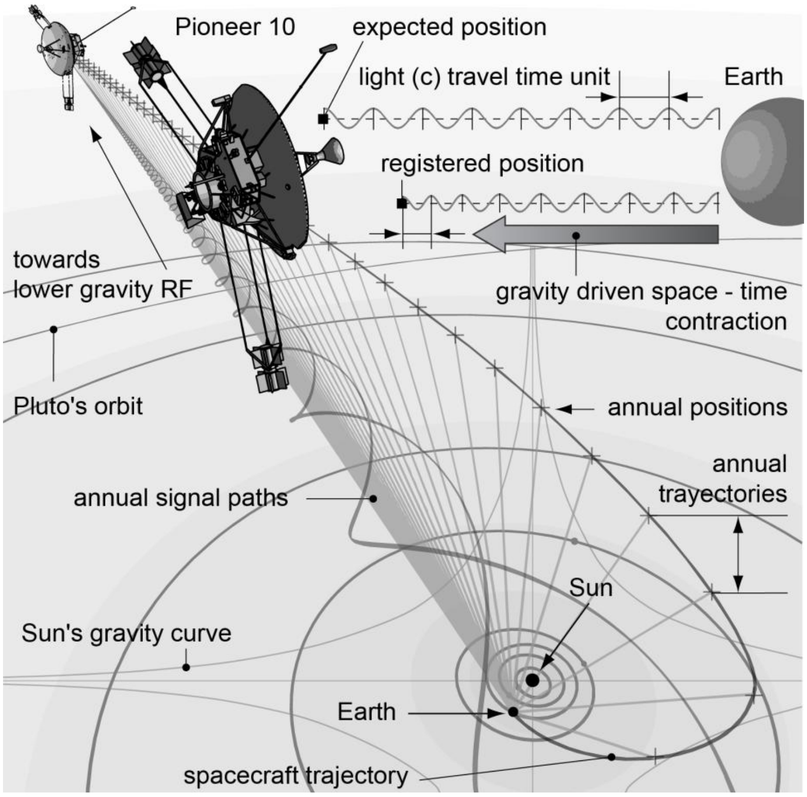

Fig 1.2.2.1 *The space-time variation of Pioneer 10 trajectory*

As its absolute frequency does not change, travelling toward Earth through space-time of longer wavelengths and wave-times, signal from Pioneer received on Earth is read with a shift toward the blue end of the spectrum (Figure 1.2.4.1).

Bearing in mind that the dilatation is the amount of change of space-time units of specific gravitational system, the Pioneer anomaly correction is done by calculation of these variables.

Although the computational operations (as described in the next chapter), due to Pioneer's nonlinear trajectory and variable positions of Earth and other planets of the solar system, is slightly more complex, the principle of calculating the anomaly is an elementary application of the universal space-time principle (0.0.8):

The time of flight *TOF*, is a duration of light speed signal journey that communicates with Pioneer. As the dilatation of time equivalents to the dilatation of space, the amount of dilated time of flight *TOFd*, expressed in seconds, is multiplied with the signal trajectory space s, expressed in meters. Therefore, it is true (1.2.2.6);

$$\Delta s = TOFds \qquad 1.2.2.6$$

which is equivalent to (1.2.2.7);

$$\Delta s = \frac{s^2}{c} d \qquad 1.2.2.7$$

Calculation of these space-time variation values, for any year of travel, is equivalent to recorded amount of Pioneer's slowdown Δs (Chart 1.2.3.1). Accumulated amounts are also equal to those observed (Chart 1.2.3.2).

1.2.3 Method

Although both twin spacecrafts data showed the same "negative acceleration towards Sun" anomaly, for our calculation purposes only the Pioneers 10 data was used. A switch failure in the Pioneer 11 radio system on 1st of October 1990 disabled the generation of coherent Doppler signals. After that date, when the spacecraft was approximately 30 AU away from Sun, no useful data have been generated for the scientific investigation.

For this reason, in computer model construction, the 28-year trajectory data of Pioneer 10 was used (Table 1.2.3.1).

was launched on	02. 03. 1972
first data available	03. 03. 1972
last data available	30. 12. 2000

data from 02. 03. 2000

elliptical heliocentric position x (AU)	16,941232
elliptical heliocentric position y (AU)	-72,629043
elliptical heliocentric position z (AU)	3,957741
elliptical heliocentric longitude	76° 52" 12'
elliptical heliocentric latitude	03° 02" 16'
heliocentric distance (AU)	74,683645
distance from Earth (AU)	74,601270

Table 1.2.3.1 *Basic data of 28-year Pioneer 10 trajectory*

The high degree of approximation, described in detail below, is irrelevant in explaining the nature of registered deceleration of the probe.

In the anomaly solution the computer simulation was used.
From the program Planet Orbits of Alcyone Software, Pioneer 10 trajectory data was uploaded in Maya (Autodesk). (pioneer_10_POrbits_trajectory.mb) (Figure 1.2.3.1 - 4).

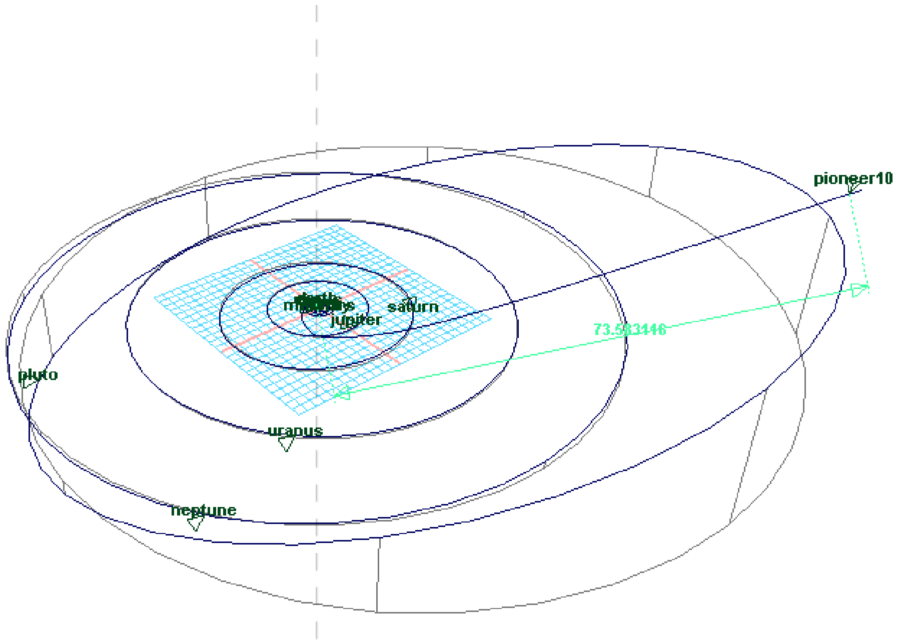

Figure 1.2.3.1 *Computer model of Pioneer 10 trajectory - Perspective view*

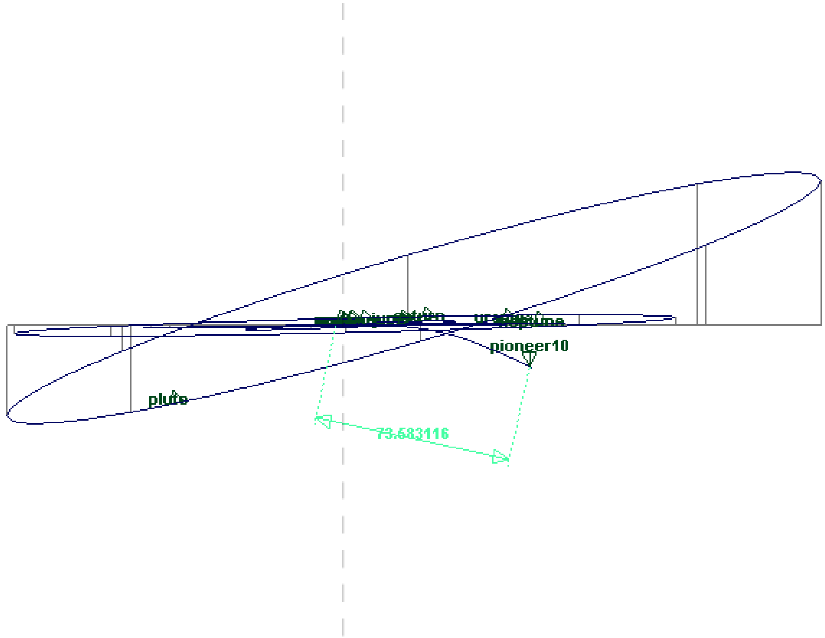

Figure 1.2.3.2 *Computer model of Pioneer 10 trajectory - Frontal view*

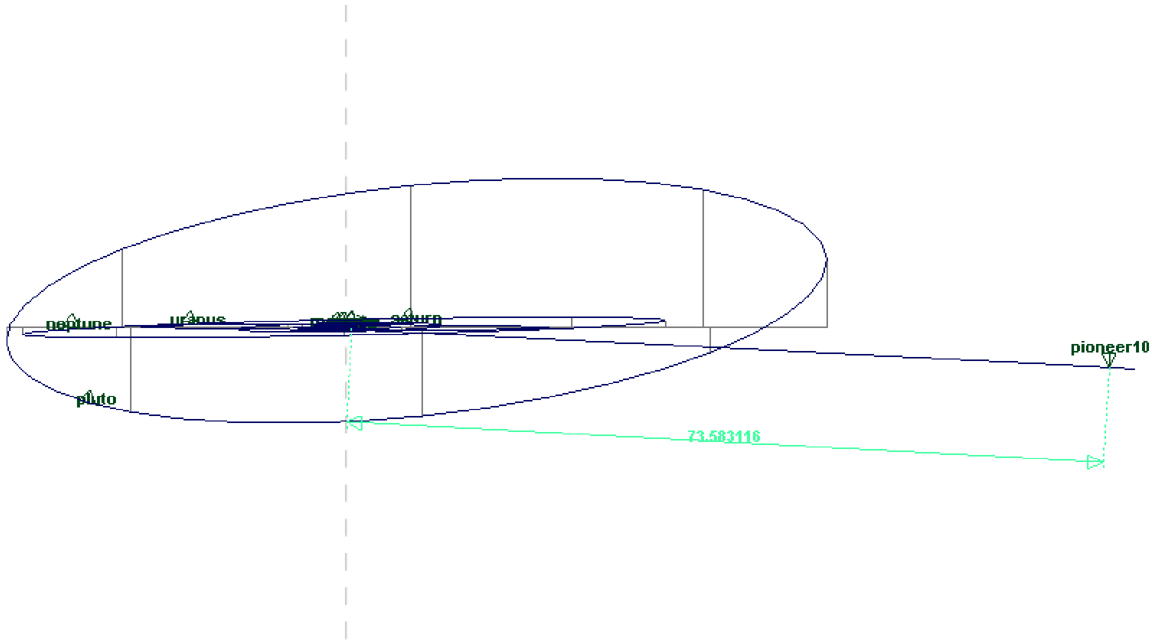

Figure 1.2.3.3 *Computer model of Pioneer 10 trajectory - Side view*

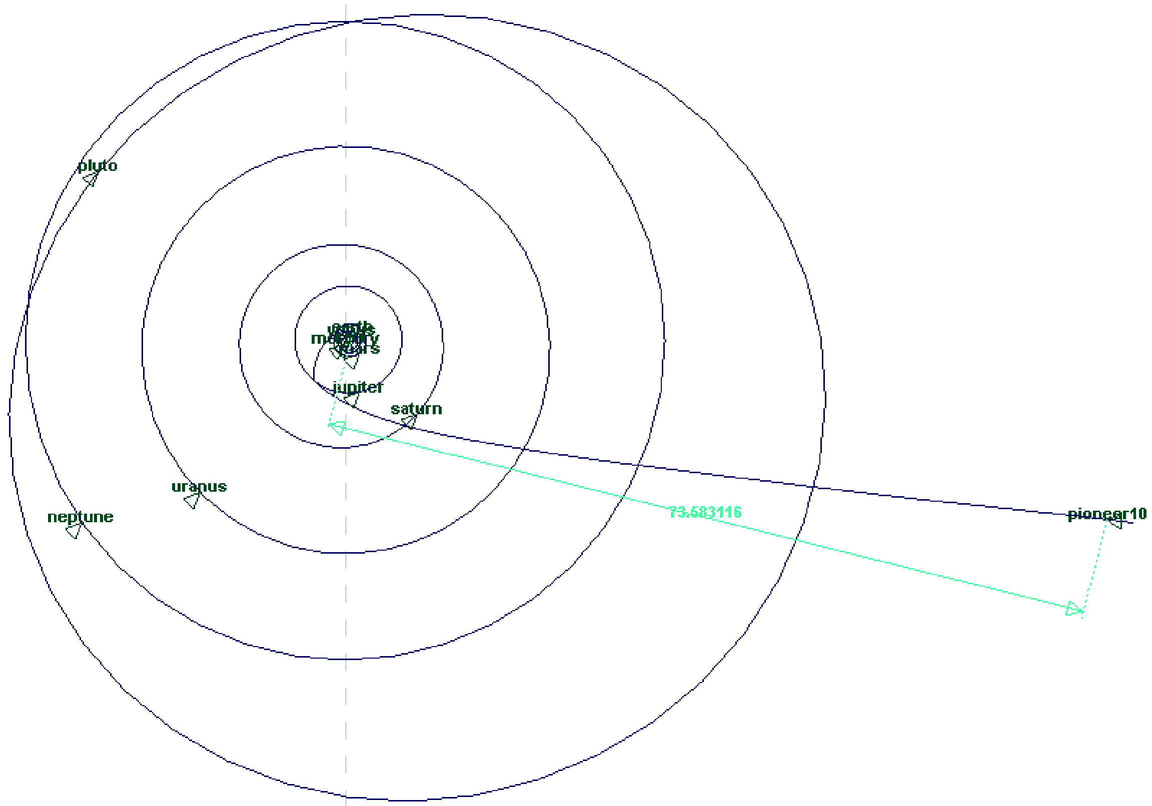

Figure 1.2.3.4 *Computer model of Pioneer 10 trajectory - Top view*

Trajectory of the probe is divided into regions of annual distance travelled (Figure 1.2.3.5).

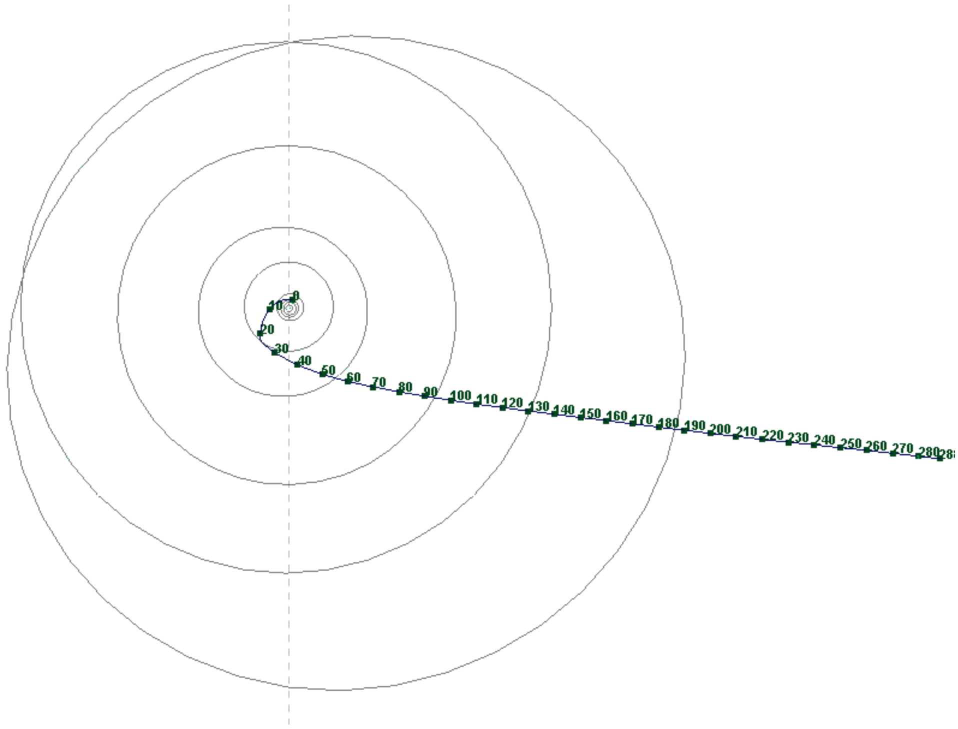

Figure 1.2.3.5 *Trajectory of the probe divided into regions of annual distance travelled*

Among all created positions and Earth, withdrawn were paths of signal trajectory which establishes the annual communication with the spacecraft (Figure 1.2.3.6). Although this process took place in different orbital positions of Earth around the Sun, in the computer constructed model, communication is taking place exactly ones per year. Thus, the position of the Earth is fixed at the point of launch day. Its variable position in orbit around the Sun would produce oscillations in the output graph, consistent to real data, but since mentioned has no impact on its main line and has no affect on the solution of the anomaly, these data were ignored.

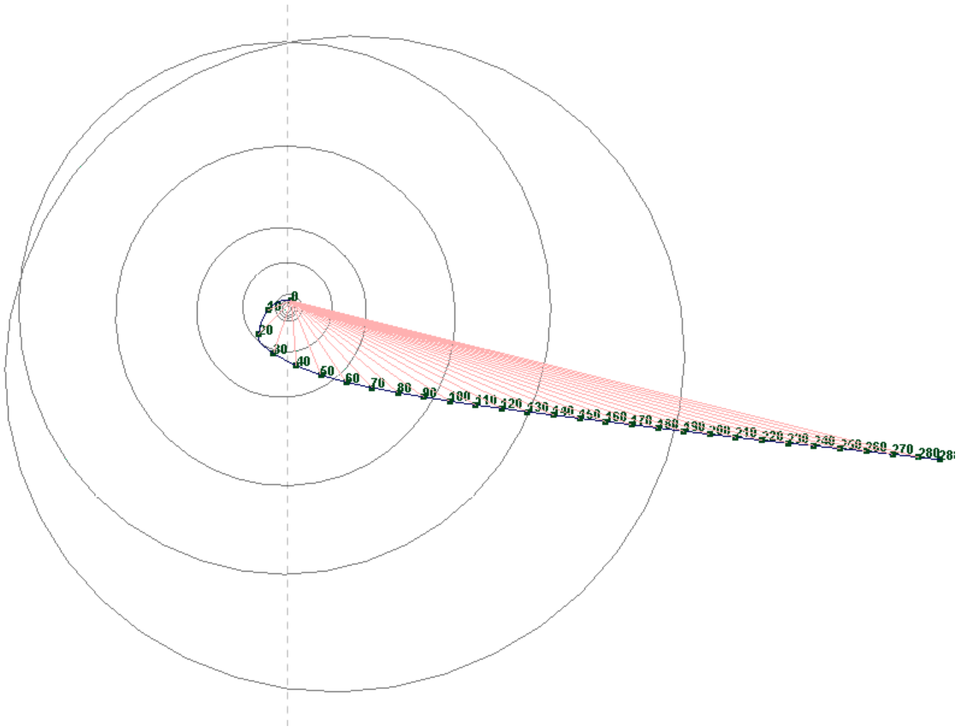

Figure 1.2.3.6 *Routes of signal trajectories which establish the annual communication with the spacecraft*

Lines of signal trajectory between the annual positions of Pioneer and Earth were divided into regions whose number is equivalent to the number of years of flight of corresponding positions on Pioneers path (Figure 1.2.3.7).

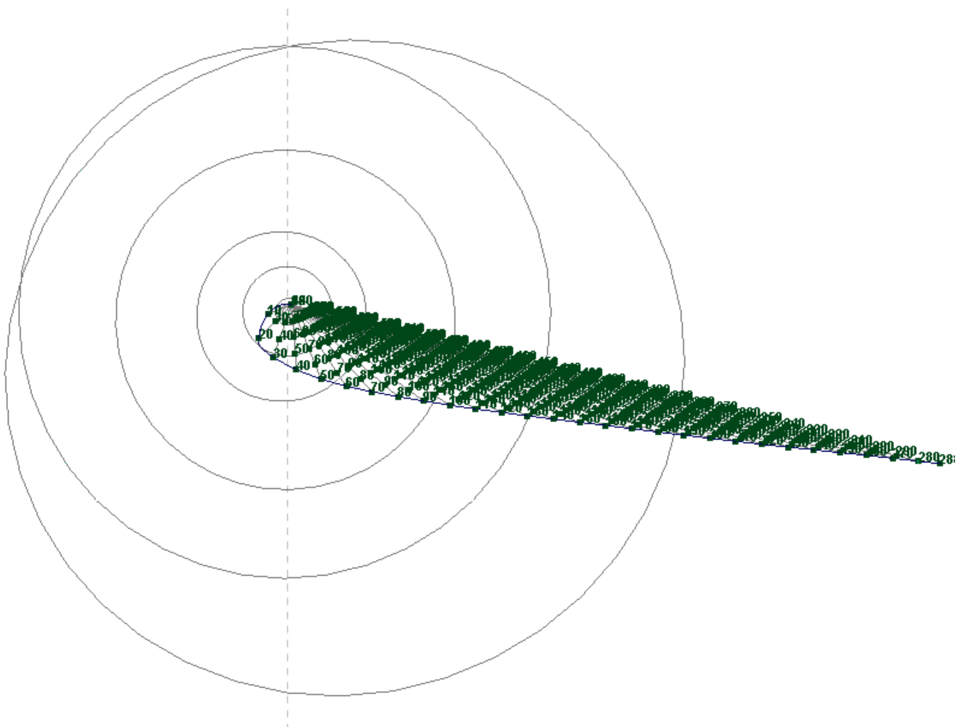

Figure 1.2.3.7 *Lines of signal trajectories divided into regions.*

To each trajectory a locator that moves along a straight line from the point of the annual Pioneer positions toward Earth is assigned. Animated locator represents signal communication with the probe. To each signal the distance tool from the Earth and the Sun is assigned (Figure 1.2.3.8).

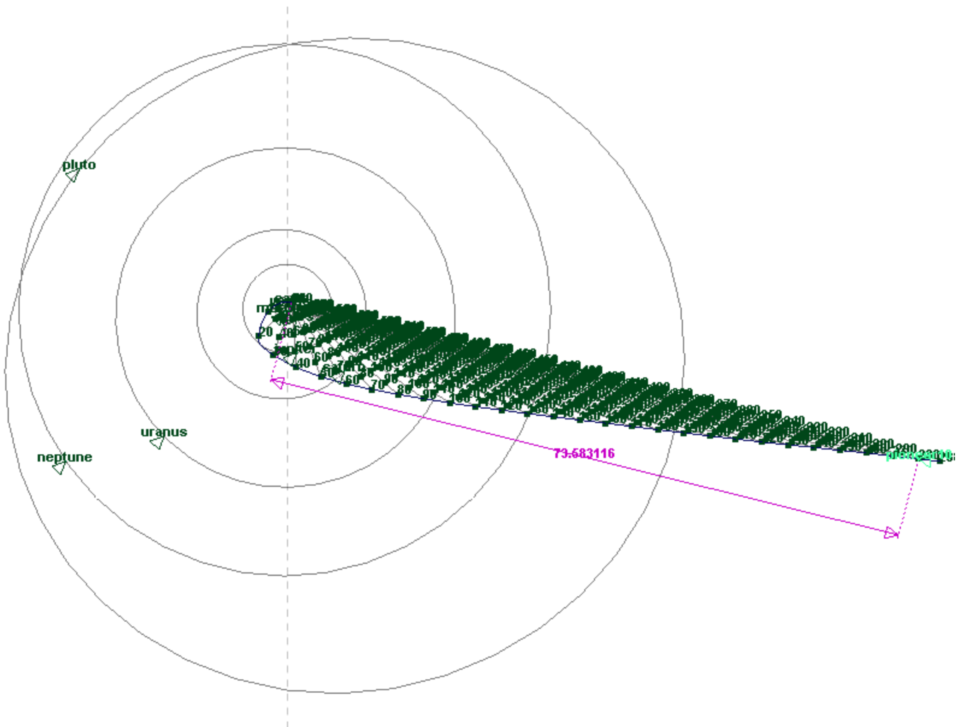

Figure 1.2.3.8 *Measuring tools from the Earth and the Sun assigned to animated signal that moves along the corresponding path of its annual communication.*

More accurate model would include the gravitational influences of other planets on dilatation of referential system from which we measure and the positions through which the signal passes, but as these minor fluctuations do not affect the explanation of the anomaly, mentioned effects are neglected. Figures (1.2.3.9 - 12) display a model described above, showing Pioneer 10 trajectory in various stages of flight time, with a red circle highlights the position of the probe. Computer animation of the described model is shown in movie clip Pioneer 10 trajectory.

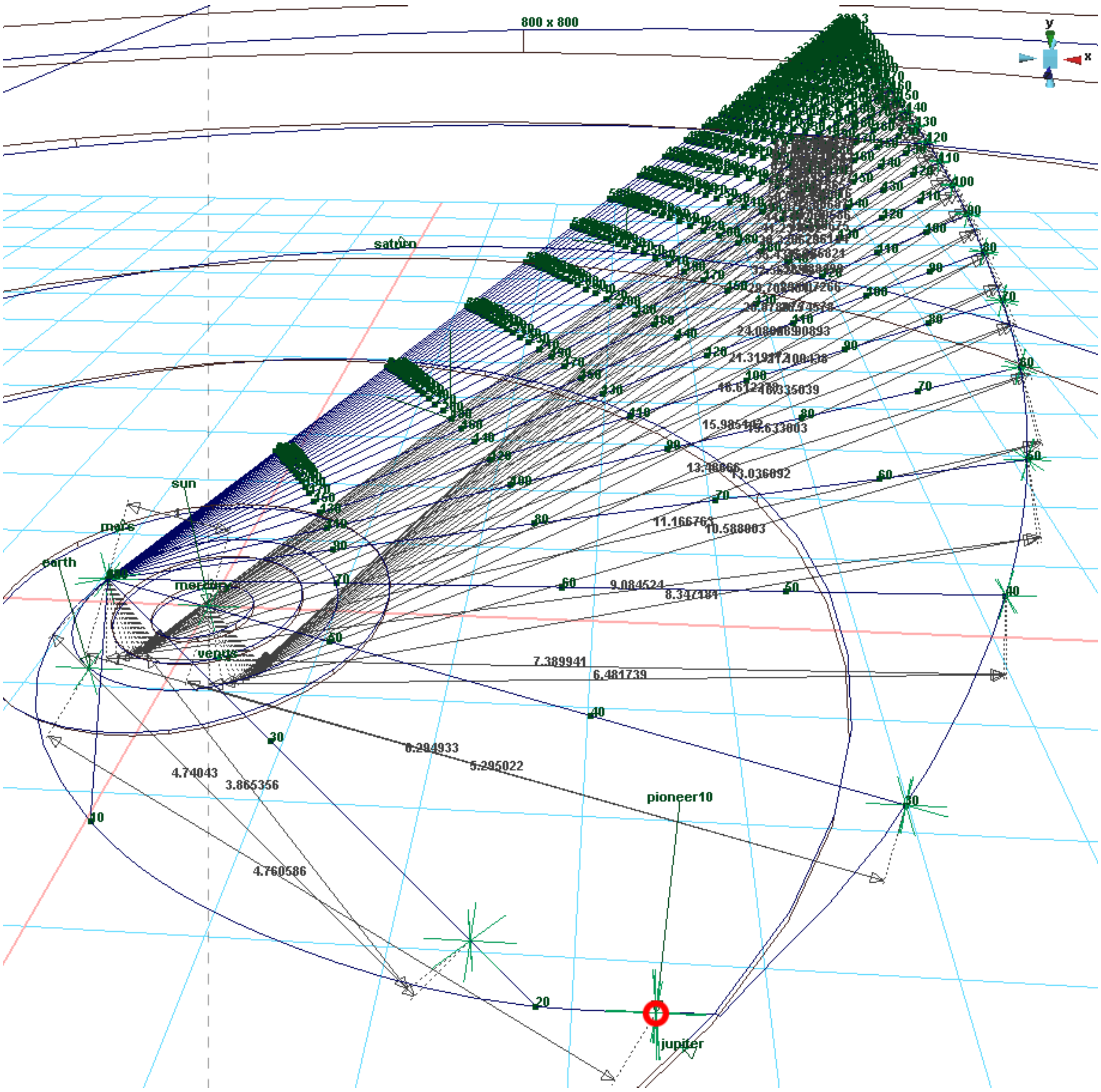

Figure 1.2.3.9 *Pioneer 10 and Jupiter converge towards the position of their encounter. After that event, Jupiter's gravity alters the direction of the probe. Length of the squares of the grid represents the distance of 1 AU.*

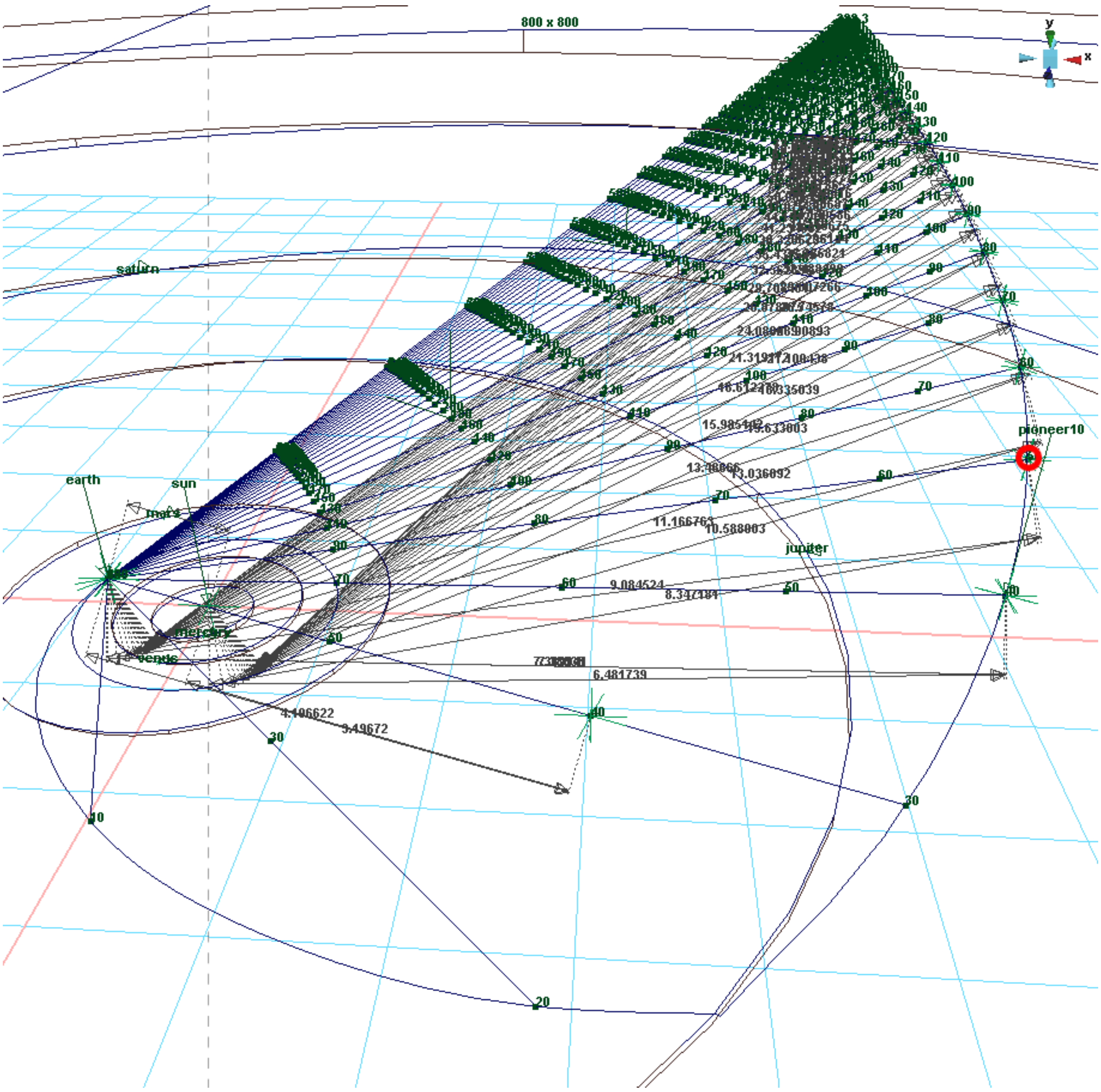

Figure 1.2.3.10 *The fifth-year of probes travel.*

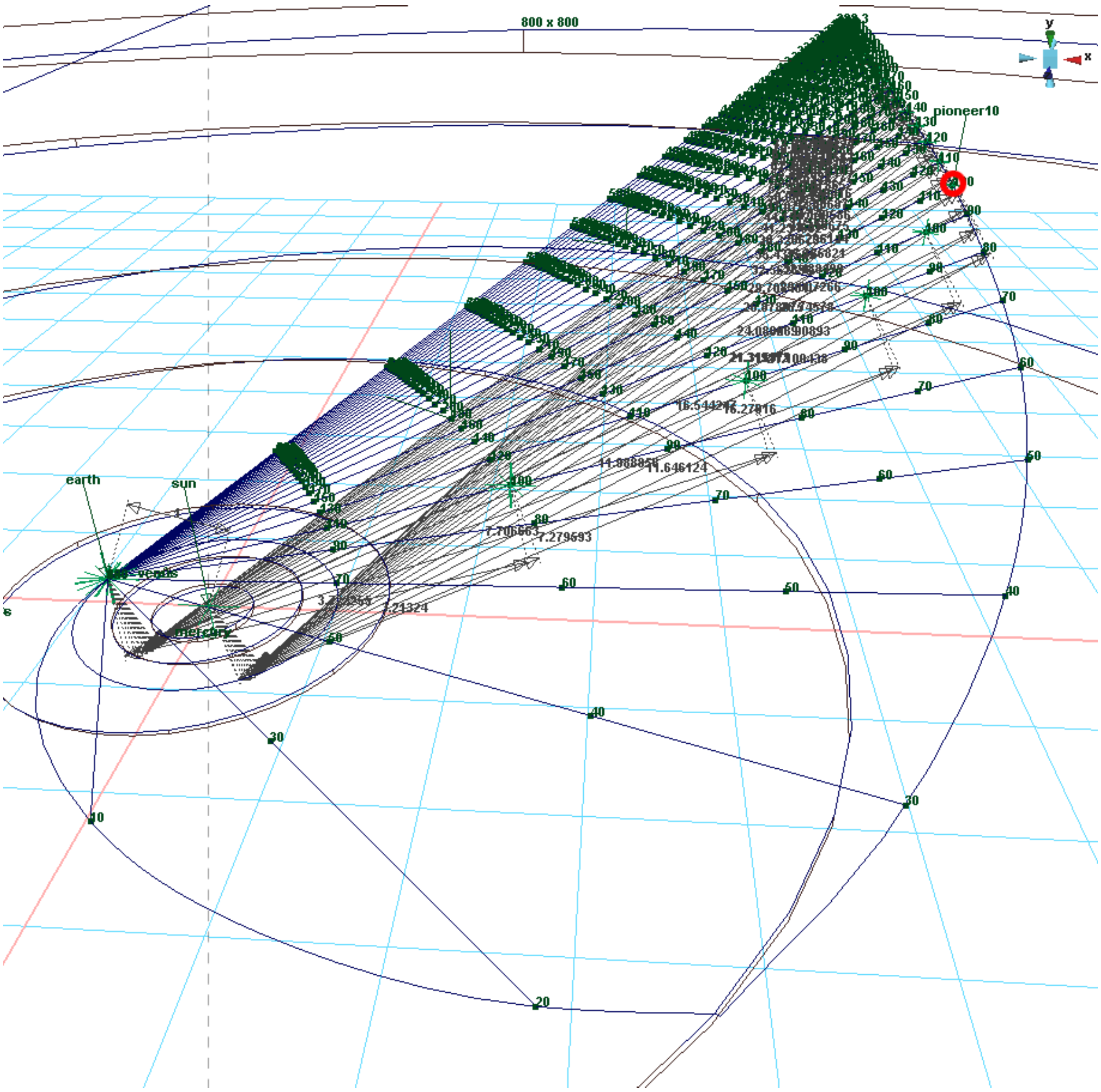

Figure 1.2.3.11 *The ninth-year of probes travel.*

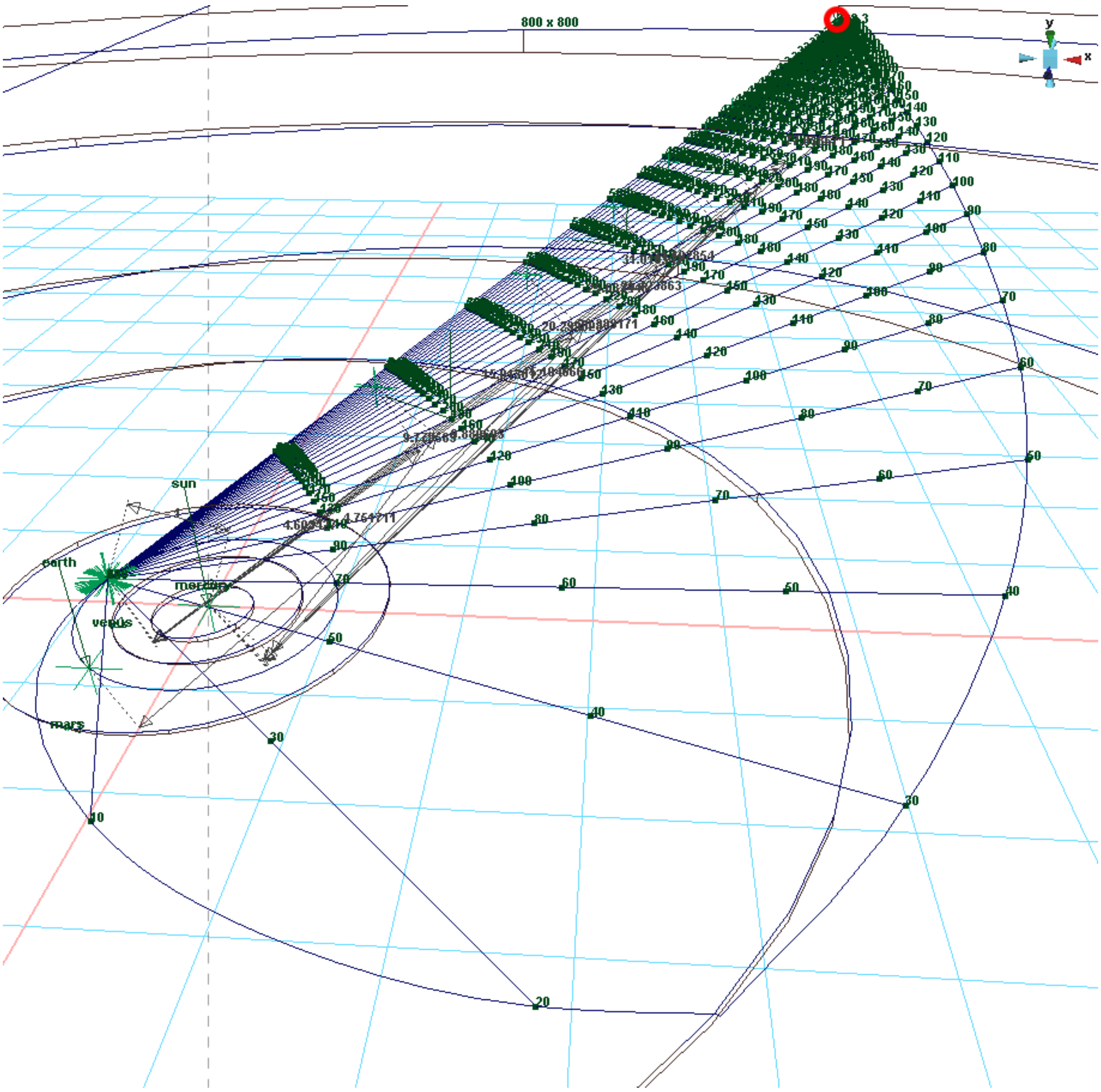

Figure 1.2.3.12 *The twenty-eighth year of probes travel*

Recorded distance data are read from described signal positions and from half of the distances between them. A smaller or larger number of readings would result in varying degrees of accuracy, which does not affect the explanation of the anomaly.

In what follows, capital letters in brackets indicate the column in the table Pioneer_anomaly_solution.xlsx.

For each year, the described distance scales expressed in AU, were entered into Microsoft Excel (C, D). Because of the rigidity of principle, the degree of precision of highly professional computing programs was not required.

For all signal lines positions described, according to the valid equations for gravity and dilation (0.0.36, 0.0.33, 0.0.7), calculated are dilatations d_{on} recorded at orbital distances from Earth d_{Eon} (H) and the Sun d_{Son} (G). The same values, with the mentioned correction (0.0.6), are obtained by Schwarzschild formula for the calculation of gravitational dilation (0.0.1). From the sum of these values d_{Son}+d_{Eon} (I) calculated are dilatation differences of registered points in relation to the dilatation of the Earth in the

solar orbit, i.e. in relation to space-time system from which we measure d_n (J). These results (J) are multiplied by the time of flight TOF (L) portions of the space between the measured positions on the trajectory of the signal lines (K). The annual sum $\Sigma TOFd_n$ (Q) of values obtained $TOFd_n$ (M) represents the dilatation of time, at lines on which the signal travels at the speed of light, i.e. the dilatation of time of flight TOF, relative to Earth's time in Sun's orbit.
For calculating the annual slowdown scale, from each annual result the previous year result is subtracted (Q). This amount represents the annual difference of one-way flight time dilation $\Delta\Sigma TOFd_n$. Although the signal travels two-ways (RTLT), so when determining the distance the time of its flight is halved, in described case the duration of one-way signal flight is multiplied by two.
This is because the Pioneer, although much slower than light signal, acts by the same laws of space-time environments through which it passes. In other words, within its area of smaller space-time compared to the Terrestrial, the probe moves at unaltered speed. Measured from the Earth, the probe slows down. Dilatation of ten hours one-way signal flight is information of space-time portion variation, equivalent to 28 year portion of probes trajectory (due to the nonlinear trajectory of the probe it is the approximate equivalence). According to a valid statement (0.0.8), dilatation of time equals the space dilatation. Thus, for expressing the Pioneers annual deceleration in spatial units, described double time dilatation difference $2\Delta\Sigma TOFd_n$ (R), expressed in seconds, for each year is multiplied by the corresponding length of the annual signal trajectory differences (N), expressed in meters.
The results obtained $2\Delta\Sigma TOFd_n s$ (S) draw a graph of Pioneers annual deceleration, equivalent to empirically registered (Chart 1.2.3.1).

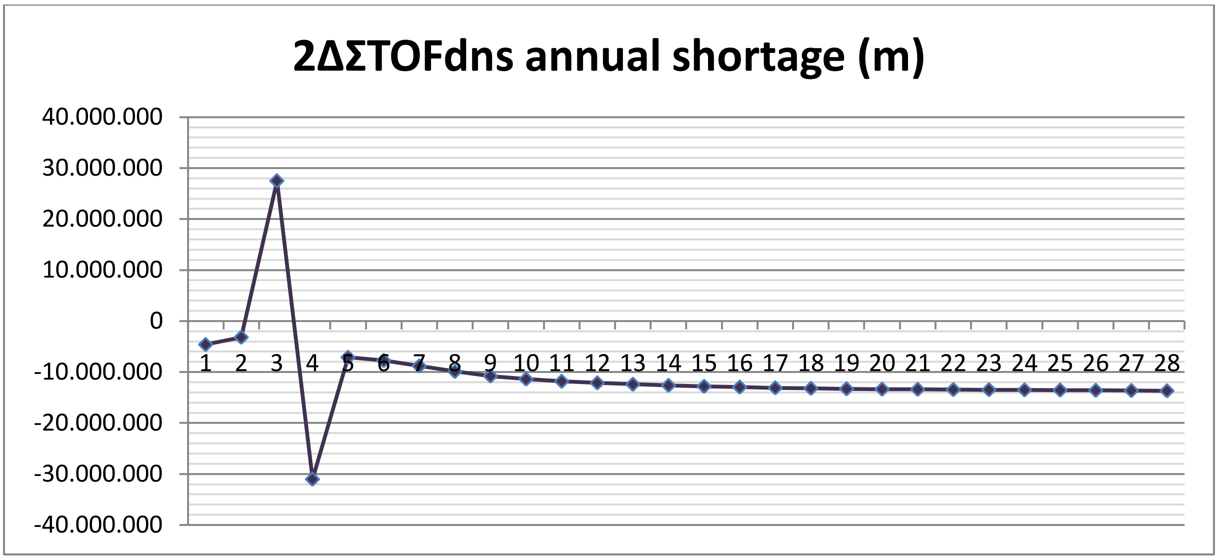

Chart 1.2.3.1 *Graphical presentation of Pioneer 10 probes annual deceleration. X coordinate represents time expressed in years, while is Y coordinate represents space expressed in meters.*

The annual scale of mentioned dilatation differences products $2\Delta\Sigma TOFd_n$ (R) and the lengths of the signal trajectory Σs (A), draw the graph line of differences accumulation between the expected positions of the probe and those registered $2\Delta\Sigma TOFd_n\Sigma s$ (T), also equivalent to empirically observed (Chart 1.2.3.2).

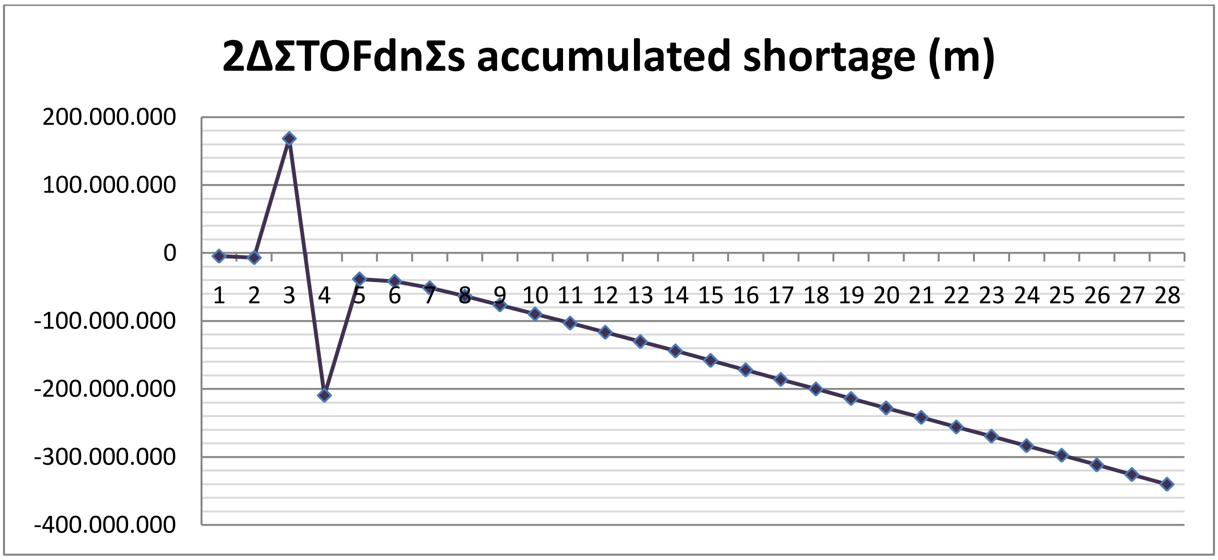

Chart 1.2.3.2 *Graphical presentation of the accumulated difference between predicted and observed positions of the probe.*

The jump in both charts is the resultant of dilatation differences caused by the construction of computer simulation. The path of signal trajectory between Earths and Pioneers position in the third year of the flight, went through almost the same point at which is the Sun, whose position coincided with the position of a marker from which dilatation was read (Figure 1.2.3.9 - 12).

1.2.4 Conclusion

Despite the high degree of approximation, the results of the implementation of a valid principle (*g=cd*), plot curves equivalent to Pioneers deceleration record. The exact time data of establishing communication and calculation of gravitational influences of planets of the solar system would produce a copy of the actual data curve.

Opposite to contradict Relativistic concept, where due to universally fixed speed, dilatation of space and time are counterintuitive mirror symmetrical (expansion of time⇄contraction of space ...), a valid principle (*g=cd*), is a scalar space-time variation, which consequently measure constant speed of light. Due to constancy of velocity scalar, information of space dilatation is read through the information of dilation of time and vice versa.

Pioneer "anomaly" measured the nature of the gravitational wave.

As with the Pound-Rebka experiment, when the Pioneer measured the progress of moving away from Earth, unexplainable acceleration of our planet would be equivalent to observed deceleration anomaly of the probe. The signal transmitted from Earth would have a shift towards red, mirror symmetrical to shift toward the blue end of the spectrum of signal emitted from the Pioneer and registered on Earth (Fig. 1.2.4.1).

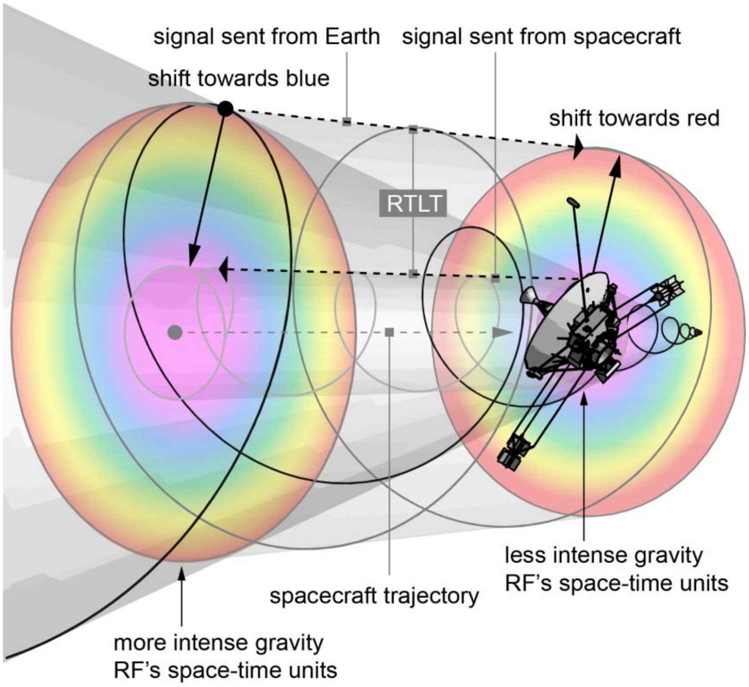

Figure 1.2.4.1 *Graphical presentation of space-time relations among different gravity fields on the Pioneer 10 model.*

In the described scenario, the Earth is the bottom and Pioneer is the top of the tower in Pound-Rebka experiment.