Alternative Reflections on the "Pioneer Anomaly"

Johann Albers

Formerly: Fachbereich Physik der Universität des Saarlandes
66041 Saarbrücken, Germany
e-mail: johann.albers@t-online.de

ABSTRACT

Since the unexpected acceleration effects of the so called Pioneer anomaly were realized, an enormous number of articles appeared with possible explanations of this mystery. Meanwhile, however, an anisotropic radiation pressure due to heat loss is commonly accepted as source of this acceleration. On the basis of the Alternative Reflections on Gravitation (ARG), however, a quite different source must be expected: When a satellite moves in the sea of gravitons it produces retarding forces, proportional to its speed v and against the direction of its motion, comparable to a ship when it moves on the ocean. The projection of these retarding forces towards the line of sight determines the anomalous acceleration of the Pioneer anomaly. The behavior of this acceleration can easily be calculated by use of freely available positional data of both Pioneer satellites. The calculated data, however, appear to be so confusing, that it is understandable, that most of the related Doppler-data were not published. In the case of Pioneer11, data are available of the anomalous acceleration at distances behind the Saturn-Flyby. And these data are very well compatible with the results of the ARG-calculations.

1. INTRODUCTION

"The Pioneer anomaly or Pioneer effect was the observed deviation from predicted accelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed about 20 astronomical units (3×10^9 km; 2×10^9 mi) on their trajectories out of the Solar System. The apparent anomaly was a matter of tremendous interest for many years, but has been subsequently explained by an anisotropic radiation pressure caused by the spacecraft's heat loss.", [1].

On the basis of the "Alternative Reflections on Gravitation", "ARG" [2], [3], however, the observed deviations from the expected accelerations must not result from an anisotropic radiation pressure, but may well be expected from principles which, however, are not compatible with classical theories of gravitation, Newtonian Mechanics or Relativistic Mechanics.

2. ARG-EXPECTATIONS CONCERNING PIONEER-FLIGHTS

The basic ideas of the ARG are the following: Inside the hot interior of stars Axion or Axion-like-particles (Alps) are produced, which escape their stars without any interaction, but cary some amount of mechanical impulse. During the flight away from their star, the Alps convert to gravitons which interact with baryonic matter, transfer a part of their impulse and thus produce repulsive forces, as the primary gravitational effect. The mutual shielding of two masses against one another leads to the attractive forces according to Newton's law gravitation. If an object with a certain mass is resting in the sea of gravitons, the repulsive pressure is equal from every direction and thus does not lead to an effective force. If this mass, however, is moving with a speed v, a resting observer expects that the amount of gravitons which travel with c,the speed of light, and interact with the mass, has no isotropic symmetry. The amount of gravitons which appear from ahead during a certain time interval is by a factor (1+v/c) higher than for the resting mass. The amount of gravitons which deliver their repulsive force from behind of the satellite, is lower by a factor (1-v/c). Both

effects lead to an effective force antiparallel to the direction of the motion of the satellites and proportional to the speed v.

Measurements by use of the Doppler effect always deliver data which are valid for the line of sight. Regarding this fact one can formulate the expectations on the basis of the ARG concerning the Pioneer anomaly by a single sentence: The anomalous acceleration of the Pioneer anomaly is proportional to the projection along the line of sight of the satellites speed of motion.

3. VISUALIZATION OF THE EXPECTED ANOMALIES

While the measurements of the anomalous accelerations need the high resolution of the Doppler effect, the prediction of these accelerations can be performed by use of data with far lower resolution: The positional data of the flights which are freely available for everybody per internet from NASA sites. Two sources will be used here. The first is a graphic which is used to explain lucidly what can be expected [4], the second is a database [5] which allows the calculation with a sufficiently high resolution.

In the graphic, one can see the orbits of several satellites. Especially the path of Pioneer11 may be considered here as an example. The distances between the yearly marks, which define the positions with a high pixel resolution, are a rough measure of the speed. The projection of the speed along the line of side towards Earth, or corrected for the position of the Sun, can be judged by eye. What can be expected? The flight starts and receives high speeds away from Sun and Earth. When the flyby around Jupiter happens, the observed acceleration approaches zero. After this flyby the distance towards the Sun decreases, leading to negative values of the anomalous acceleration. At the beginning of 1976 the acceleration again changes its sign, because the distance starts to increase. The positive sign remains for the future. The amount of the acceleration decreases towards zero at the beginning of 1980, when the satellite moves perpendicular to the line of sight during the Saturn flyby. From that time the acceleration increases, because the direction of motion approaches more and more the line of sight. After running through a broad maximum the acceleration decreases slowly, due to the decrease of the speed, caused by the attractive gravitational forces towards the Sun.

4. CALCULATION OF THE EXPECTED ANOMALIES

After the qualitative description of the expected anomalies in the foregoing chapter, a more quantitative one will be presented here. From a NASA database [5] the necessary data can easily be obtained. In order to enable everybody to reproduce the results of this paper, the procedure is explained here point by point. In [5] one may choose "Create file", "Pioneer11" as object, "Solar Ecliptic", start year "1973", start day "100", Stop year "1999", Stop day "365", Time resolution (in days) "100".

The achieved data, however, describe the positions in a spherical coordinate system and must be converted to a Cartesian system. In this system the speed and its direction, as well as the direction of the line of sight can easily be obtained. This allows the determination of the interesting values of the projection of the speed along the line of sight. The obtained results of speed and projection are presented in Fig.1. While the course of the speed is well compatible with expectations, the course of the projection is so confusing, especially before the Saturn-flyby, that it is unsuitable to be explained and published as the source of the Pioneer anomaly. Far behind the Saturn-flyby, at flight times above about 4000 days, the projection seems to be rather stable at values which enabled the

publication of the well known constant value of the Pioneer anomaly.

5. DEPENDENCE OF THE ANOMALY ON DISTANCE

In order to enable a comparison of the above described results with corresponding published data, in Fig.2 the values of the projection of Pioneer11 are drawn against the distance from the Sun, beginning after the Saturn-flyby, shortly before 10 AU. Enclosed are also data of Pioneer10, which are determined in the same way as described above for Pioneer11, but beginning after its Jupiter-flyby at about 5 AU. Both satellites show a similar behavior after its last flyby, which, however, can't hardly be described by a constant value of an anomalous acceleration. In the case of Pioneer11 a comparison between Fig. 2 and Fig.7 in a paper of Anderson et al. [6] is possible.

6. EXPERIMENTAL RESULTS FROM DOPPLER DATA

There exists, however, a noticeable difference between the data in Fig.2 of this paper and those in Fig.7 in the relevant paper by J. D. Anderson [6]. In the last case the anomalous accelerations of both Pioneer satellites seem to be of similar amount. In the same paper, however, there are also mentioned values of a_p which are slightly higher for Pioneer11 then for Pioneer10, $(8.09\pm0.20)\times 10^{-8}cm/s^2$ for Pioneer 10 and of $(8.56\pm0.15)\times10^{-8}cm/s^2$ for Pioneer 11).

On the basis of the own results in Fig.2 the data of Pioneer10 surpass those of Pioneer11 by about 14 to 10 percent at distances between 25 AU and 50 AU. Must the discrepancy between these data and those in [6] be seen as a severe problem?

According to Turyshev and Toth [7], there exist several independent verifications of the Pioneer anomaly. One of them is concerned with an orbit determination code that was independently developed by V.T. Toth for the purposes of studying the Pioneer anomaly [8]. There are listed two data-sets which indicate, that the anomalous acceleration of Pioneer10 surpasses that of Pioneer11 by 10 to 17 percent. The values of the second set are higher for both satellites than those of the first set, but they are combined with jerk terms which describe a continuous decrease of the anomalous acceleration. The own data in Fig.2 seem to be very well compatible with those in Todt's paper.

7. TWO POSSIBLE EXPLANATIONS OF THE ANOMALY

In this paper three graphs are of interest which show the behavior of the anomalous acceleration of Pioneercraft after their last flyby. All three graphs show a similar behavior, an increase from almost zero towards a maximum and a slow decrease in the following. The first one is the report about the experimental data from Doppler measurements (Fig.7 in [6]). The second one explains the anomaly on the basis of thermal radiation pressure (Fig.8 in [9]), and the last one can be seen in this paper in Fig.2 as a second explanation. What is the difference between the two explanations?

The first model assumes a force due to the pressure of thermal radiation along the line of sight, because the main antenna of the satellites are oriented towards Earth. Thus, it is quite clear that the anomalous acceleration along the line of flight rises from zero after the last flyby. Whether the resulting force is accelerating or decelerating, can be decided only on the basis of a huge amount of data and calculations.

The second model, explained in this paper in Fig.2, assumes a retarding force along the line of flight, and predicts a vanishing value of the anomalous acceleration along the line of sight towards Earth during the last flyby, followed by an increase towards a maximum and a following slow decrease, overlapped by an annual modulation of the line of sight, due to the motion of Earth around the Sun.

Both models present similar results in their graphs. Because far behind the last flyby, the line of sight and the line of flight are close to each other, the data from this region are not very suited to decide between both explanations. Best suited are data from the region around the last flyby, where the line of flight is perpendicular to the line of sight. So one may ask: What is shown in the first graph with its experimental data, and which of the two explaining models is compatible with these experimental data? The answer is rather simple: The experimental data are concerned with the anomalous acceleration along the line of sight, just as expected from the model of this paper. The first model, however, based on the effect of thermal radiation, describes an assumed anomalous effect along the line of flight, but doesn't explain the experimental data along the line of sight. Instead, this model lets expect the full value of force along the line of sight near the flyby position.

8. CONCLUSIONS

The Pioneer anomaly is the designation of anomalous accelerations, observed by Doppler measurements during the flights of the Pioneer satellites, which are not expected from conventional gravitational theories, even if all possible sources of gravitational contributions are regarded. Very often in the enormous number of related papers and publications the question raises whether this effect demands a new type of physics.

Meanwhile, it is quite usually accepted that the anomalous accelerations can be explained by an overlooked effect due to the pressure from thermal radiation.

On the basis of the ARG, however, the Pioneer anomaly is very well a documentation of a new type of physics. Especially the published behavior of the anomalous acceleration near the Saturn flyby of Pioneer11 may be considered to decide between both explanations. While the ARG correctly describe the low values of the anomaly along the line of sight, the thermal radiation produces low anomalous values along the line of flight. It would be of the highest interest to get more extended data of the Pioneer anomaly, just from regions of the orbits, where the data appeared to be too confusing to be published, especially by use of a constant value.

Two other phenomena may be mentioned here, because both are related to satellite flights and NASA, and because both obviously demand an explanation on the basis of new physics: The Flyby anomaly and the EmDrive. While the Flyby anomaly belongs to the category of effects which can't be explained classically, the EmDrive even violates one of the basic principles of classical physics: Newton’s Third Law of Motion, the conservation of momentum. Despite of this obvious failure, a paper about the EmDrive was recently accepted by a peer-reviewed journal [10].

On the basis of the ARG, however, both phenomena, as well the Flyby anomaly [3] as the EmDrive [11] are well expected effects. But such explanations don't have a chance to be published in peer-reviewed journals, which on the other side see no problem to accept an enormous amount of papers about dark matter and dark energy, which introduce suitable new parameters to explain otherwise unexplainable phenomena. But the situation may change already in the near future, especially if the commercially interesting EmDrive can be verified by a lot of further experiments. Even the contemplations of this paper could support this trend, especially if more detailed data about the Pioneer anomaly should be in accordance with the expectations on the basis of the ARG.

Acknowledgments: The author gratefully acknowledges the possibility to use freely available and perfectly suited NASA-data of the Pioneer flights, which are used in this paper to calculate the expected anomalous gravitational effects on the basis of the ARG. These data and the derived results seem to be even more important to support the ideas of the ARG than two other NASA-

projects, the Flyby anomaly and the EmDrive, both discussed earlier by the author of this paper in contributions on the vixra-archive.

9. REFERENCES

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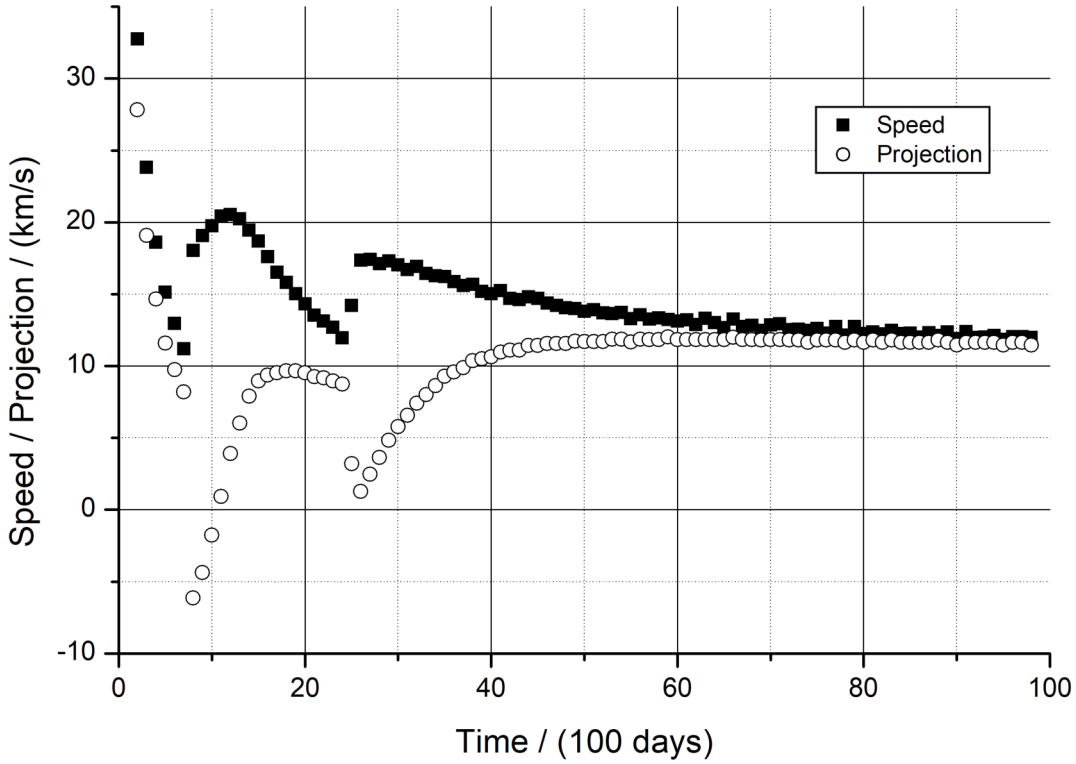

Fig.1. Dependence on time of the speed of Pioneer11 since its start, determined from NASA positional data (filled squares). The open circles represent the projection of the speed along the line of sight, which is assumed to be proportional to the anomalous acceleration of the Pioneer anomaly.

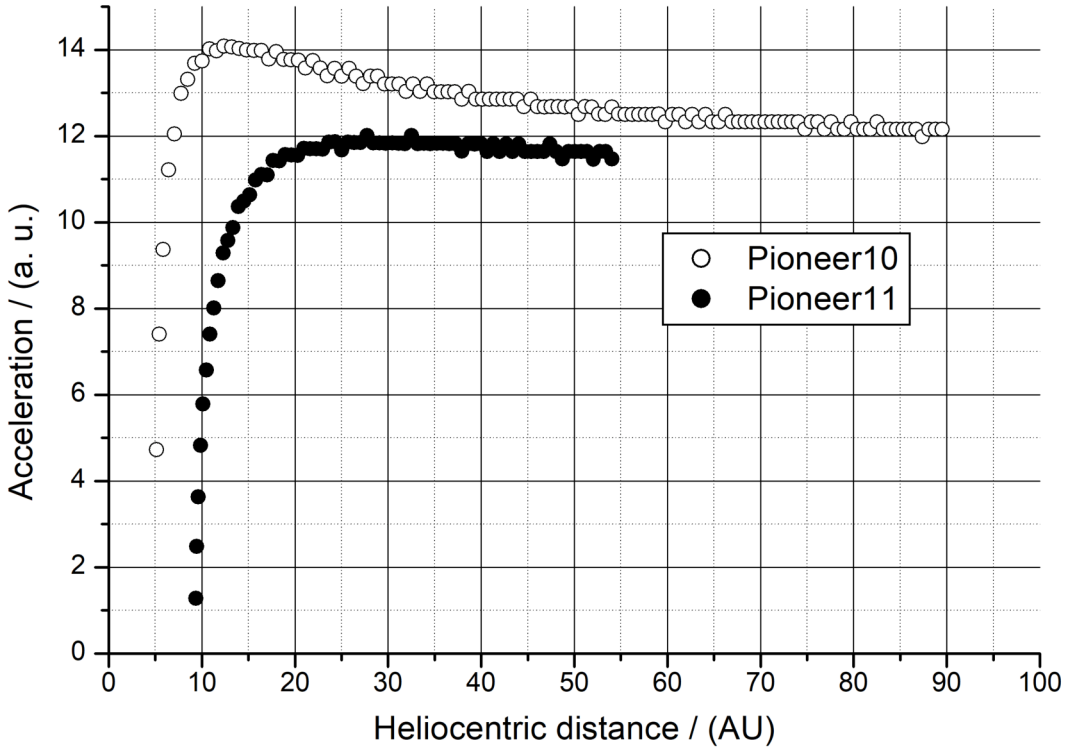

Fig.2. Calculated anomalous accelerations (in arbitrary units), along the line of sight, derived from the NASA positional data of Pioneer10 and Pioner11, behind their last flyby. These values are assumed, according to the ARG, to be proportional to the anomalous accelerations of the Pioneer anomaly.

APPENDIX

In order to illustrate the content of this paper, especially for everybody who is highly interested, but not very familiar with astrophysical problems, it may be allowed here to describe a scenario, which is very similar to the Pioneer anomaly, and may support the understanding of the above described explanations of the Pioneer anomaly for these persons.

A satellite in the sea of gravitons may be compared to a ship on an ocean. Even if the ship is resting, repulsive forces act from all sides against the ship , due to the water pressure. But the ship rests furthermore, because the resultant force is zero. If however the ship is moving with its usual speed and the drive is shutoff, what will happen? The speed of the ship will decrease, due to forces, which are approximately proportional to its speed. Of course these decelerating forces are directed antiparallel to the direction of motion.

What may an observer on land observe, if he is able to measure the distance towards the ship along the line of sight? From the evaluation of his data he easily can determine the relevant values of speed and accelerating forces. If the ship continues to follow a path away along the line of sight, the acceleration turns out to be directed towards the observer with a decrease proportional to the decrease of the speed. If the path of the ship is perpendicular to the line of sight, the acceleration is zero. If the ship moves along a path with reducing distance, the observer notices an accelerating

force away from him.

Of course, the observer knows very well, that the calculated accelerations along the line of sight are not due to an attracting force towards himself. And he also knows, that the underlying forces are produced by the ship at the position of the ship and along the direction of its motion. The Alternative Reflections on Gravitation (ARG) let expect just such a behavior in the case of the Pioneer flights, whereas conventional theories of gravitation are hardly able to explain it.

The explanations in this appendix may hopefully help to demonstrate, how easily the secrets behind the Pioneer flyby can be understood on the basis of the ARG. And they may motivate every interested reader to reproduce himself the contents of Fig.1 and Fig.2 by use of the NASA-data, within a time span of less than a day.