PIONEER ANOMALY

According to 'MATTER (Re-examined)'

Nainan K. Varghese, matterdoc@gmail.com
http://www.matterdoc.info

Abstract: Observed locations of pioneer 10 and 11 spacecrafts, after they left solar system, are displaced from their predicted positions in space and the discrepancy, which could not be explained by current physical laws, is termed as 'pioneer anomaly'. This article attempts to show that noticed discrepancy is an apparent phenomenon, produced by faulty geometry used in contemporary laws of planetary motion. In reality, spacecrafts and external efforts on them behave normally. There is no cause for assumption of strange 'forces' or mysterious effects on these spacecrafts.

Keywords: Pioneer anomaly, planetary orbits.

Introduction:

On completion of their destined roles, both spacecrafts, Pioneer 10 and Pioneer 11, were set sailing farther into space, away from solar system. They had sufficient impetus to carry themselves away from solar system, against deceleration to their motion by gravitational attraction towards macro bodies in solar system. Calculations to determine their current locations are based on existing laws on gravitational attraction and laws on planetary motion. On establishing their present locations on various occasions, certain progressive but unaccounted discrepancies were noticed. Retardations of both spacecrafts were in excess of predicted values. This phenomenon gave rise to numerous speculations and exotic theories. However, none of them could, so far, logically explain the anomaly, satisfactorily.

Contemporary laws on planetary motions are derived from empirical data collected about relative positions of few planets in solar system, with respect to assumed static state of sun. Therefore, they can be true only to determine relative positions of macro bodies in a planetary system with respect to their central body. Relative positions of a planet, moving in stable orbital path about a central body may be predicted by contemporary laws of planetary motion. Using these laws to determine other parameters of macro bodies in solar system are not right. All conclusions, expressed in this article, are from an alternative concept, presented in book, 'MATTER (Re-examined)' [1]. For details, kindly refer to the same. Figures are drawn not to scale. They are depicted only as illustration of phenomena described.

Planetary orbits:

All text books (and other literature) teach that shape of a planetary orbital path is elliptical (or circular) around its central body. At the same time, simple mechanics tells us that no free macro body can orbit around another moving macro body in closed geometrical path. Elliptical (or circular) orbital path, around a central body, is an apparent structure that suits observation, related to static central body. This

is not real path of planetary body in space. Unfeasibility to find a static macro body in space confirms impracticality of real circular/elliptical orbit around a central body. (Only stable galaxies remain stationary in space) [1]. With respect to absolute reference, real orbital path of a planet is wave-like, about central body's path, with the planet periodically moving to front and to rear of central body, as shown in figure 1. In this article, we shall ignore eccentricity of apparent planetary orbits and consider them as circular.

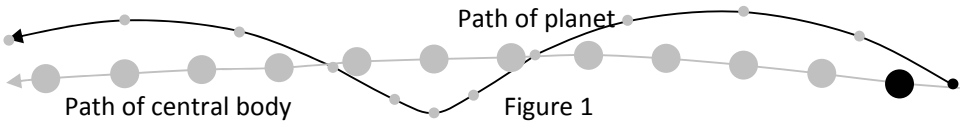

Figure 1

In figure 1, arrow in black wavy-line shows planet's real orbital path in space. Unevenness of curvatures and magnitudes of departure of path on either side of central body's path (in figure) are due to different scales used for linear and radial displacements. Path of central body is shown by arrow in grey line. This curved path, also, is wavy to a smaller extent, curving in same directions as path of planet. Path of planet's satellite is wavy-line about planet's path. Central body and planet are shown by black circles and their future positions are shown by grey circles. In this sense, it can be seen that a planet (or a satellite) orbits around centre of central body's curved path and wave pattern in its path is caused by presence of central body. Such changes in path of a free macro body may be attributed to perturbations caused by presence of nearby macro bodies. These perturbations look like orbital motion around a central body, only when they are referred to assumed static state of central body in a relatively small system of macro bodies.

Figure 2, compares real and apparent orbital paths of a planet. Blue arrow on centre line shows linear (curvature ignored) path of central body. Central body, in its present position is depicted by large black circle in the centre of planet's apparent orbital path, shown by red circle in dotted line. Large grey circles show future and past positions of central body. Planet is shown in its present position by small black circle and grey small circles show planet's future positions. Real orbital path of planet is shown by black curved line with an arrow in the direction of its motion.

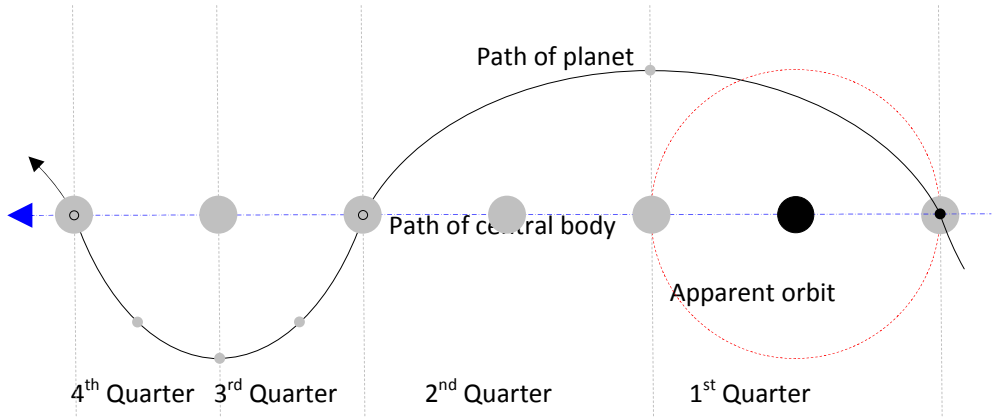

Figure 2

Real orbital path of planet may be divided into four quarters as shown in figure, separated by vertical dotted lines. Unevenness in the width of quarters is due to different scales, used in figure for vertical and horizontal measurements. Large circle in dashed red line shows apparent orbit of planet around central body, in its present position. Apparent orbit travels along with central body in its path. It is an imaginary path around central body, on which every point is equidistant from central body (for circular apparent orbit). In order to obtain apparent orbital path, we need to split real orbital path into two curved paths, one on either side of central body's path and recombine them by changing direction of planet's motion in one curved path. Apparent orbital path gives accurate information on relative positions of central and

planetary bodies and no other orbital parameters. According to concept in reference [1];

Circular/elliptical orbital paths of planets are apparent orbits around another free macro body, which the observer assumes static in space.

A planetary system can develop and sustain only (nearly) in the plane of central body's curved path.

All planets enter into orbital path from external space. Entry of a planet into its stable orbital path is a one-time process. There is no gradual development of stable orbital path for a macro body or development of a macro body in its stable orbital path.

Every planet has an ideal 'datum orbital path' about its central body. Datum orbital path is a circular apparent orbit around central body, assumed in static state. Parameters of datum orbital path depend on matter-contents of central and planetary bodies, angle of approach and linear speed of planetary body.

A planetary body may enter into its stable orbital path only through two small conical windows in space, on datum orbit, facing rear on outer or inner sides of linear path of central body.

Five eighth part of 'central force' on a planet is utilised for its orbital motion and rest, three eighth part of 'central force' is utilised for its spin motion.

(Datum) point(s) at which a planet attains highest/lowest linear speed need not coincide with perigee/apogee of its (elliptical) apparent orbital path.

Equation (16/13), in reference [1], $-\alpha = \mathrm{Sin}^{-1}\frac{u}{V}$, gives limit of drifting rate at the point of entry (from within datum orbit) for macro bodies, which may form successful stable orbits about a central body. [Where, α is angular drifting rate (rate of change of $\angle$ TbE in figure 3) between planetary body's current direction of absolute linear motion and tangent to orbital path, u is magnitude of planetary body's radial velocity towards central body by part of 'central force' and V is planetary body's absolute linear speed]. Datum orbit is smallest (circular) apparent orbital path corresponding to parameters of central and planetary bodies.

Macro bodies, approaching datum orbit from within, with higher (negative/clockwise) drifting rate, $(-\alpha)$, than value, given by above equation, flies away from central body. This is current states of both spacecrafts, Pioneer 10 and Pioneer 11. They are moving away from solar system. At the instant, when spacecrafts left surface of earth, they had their absolute linear speed, inherited from motions of earth. While they were inside solar system, within and without earth's influence, their absolute linear speed increased due to various impetuses. Their datum (apparent) orbital paths, around sun, continued to enlarge due to increases in absolute linear speeds, angles of approach to datum orbit and increases in distance from sun. By the time spacecrafts reached limit of solar system, their absolute linear speeds could over-compensate their displacements due to gravitational attraction towards sun.

Once outside solar system, there are no external influences on spacecrafts that could increase their absolute linear speed. From then onwards, absolute linear speeds of spacecrafts are continuously reduced by gravitational attraction towards sun. As distances from sun increase, gravitational attractions on spacecrafts gradually reduce. If their absolute linear motions survive even after gravitational attraction towards sun becomes negligible, they will become wholly free from solar system to be free macro bodies in galaxy. We shall limit discussion only to parameters of one of the spacecrafts.

Spacecraft, leaving solar system:

Before spacecraft, reached outskirts of solar system, it was moving in (sort of) unstable orbital path, constantly under control of various external efforts that guided its motion. Any discrepancy in displacement was readily corrected by guiding efforts. Anomaly in spacecraft's displacement was noticed after it passed about 20 au on its way out of solar system. At this distance, spacecraft had no guiding influences other than gravitational attraction towards solar system (sun). From its part of space, whole matter-content of solar system could be considered as concentrated at centre of Sun.

When spacecraft is at this distance, it is under two separate impetuses.

1. Additional work, associated with its matter-content and additional work gained from motion of

solar system (and earth), before spacecraft was launched, tends to move it along with solar system in the direction of motion of sun. During spacecrafts' travel through solar system, additional work is modified by various efforts, which guided spacecraft away from solar system. Additional work, associated with spacecraft tends to move it at a constant linear speed in straight-line path, deflecting outward from sun's path. Path of spacecraft, at any instant, is a part of its (unstable) real orbital path.

2. Simultaneously, gravitational attraction towards solar system tends to accelerate spacecraft towards sun (decelerate its outward motion).

Action of (deceleration) gravitational attraction is always towards sun. However, direction of motion due to associated additional work depends on curvature on (unstable) real orbital path, at its current location. Location of this point is bound to make considerable variation in resultant actions on it. In current theories, direction of linear motion of spacecraft, along its apparent orbital path, is ignored. Only displacement of spacecraft in the direction, away from central body is considered.

A spacecraft, when on earth, shares earth's absolute linear speed. Once it leaves earth's influence, it becomes an independent macro body, flying towards and trying to enter into its datum apparent orbit around sun. However, in case of any spacecraft designed to fly away from solar system, it becomes an independent macro body only after all external influences on it cease.

In order to make explanations simpler, we shall consider a spacecraft rocketed from central body in a two-body planetary system consisting of spacecraft and its central body (representing solar system). If spacecraft's linear speed is greater than escape velocity on central body and its direction of motion is right, it will move towards its datum apparent orbit around central body. Since datum apparent orbit is around and away from central body, spacecraft is approaching datum apparent orbit from within. A macro body, trying to enter its datum apparent orbit has to do so through any of two windows at rear of its (future) real orbital path [1]. Therefore, a spacecraft, designed to leave solar system has to enter its datum apparent orbit, somewhere in first or third quadrant of its real orbital path (as shown in figure 2), preferably nearer to second or fourth quarter.

Pioneer Anomaly:

Establishment of stable orbital path by a spacecraft depends on its parameters. For a stable orbital path, magnitude of drifting rate of orbital path, $-\alpha$, should be between that given by equation (16/13), $-\alpha = \mathrm{Sin}^{-1}\frac{u}{V}$, and equation (16/7), $-\alpha = \mathrm{Sin}^{-1}\frac{u}{2V}$, in the book 'MATTER (Re-examined)' [1]. If it is designed to leave solar system, magnitude of drifting rate of orbital path, $-\alpha$, should exceed value given by equation (16/13), $-\alpha = \mathrm{Sin}^{-1}\frac{u}{V}$. Drifting rate, $-\alpha$, may be increased either by increase in spacecraft's radial speed, u, towards solar system or by a reduction in its absolute linear speed, V. Since spacecraft is moving away from sun, magnitude of gravitational attraction between them gradually reduces. Hence, radial velocity, u, cannot increase. It can only diminish in magnitude.

Other option, left to increase drifting rate, $-\alpha$, is to reduce spacecraft's absolute linear speed. This is achieved by its gradual and diminishing deceleration by gravitational attraction towards solar system. Because of higher drifting rate ($\angle$ TbE in figure 3) and larger deflection angle ($\angle$ HBE in figure 3), spacecraft slows down its linear motion. Spacecraft moves away from solar system and continuously loses additional work derived from its parent macro body and received from other sources during its travel, within solar system. As spacecraft is destined to leave solar system, its absolute linear speed is not reduced to such an extent as to provide drifting rate, suitable for stable real orbital path. Nevertheless, attempt continues until influence of solar system on spacecraft becomes negligible.

Magnitude of spacecraft's deceleration is directly related to magnitude of gravitational attraction towards solar system, approximate value of which is given by equation in Newtonian gravitational laws. This equation needs slight modification to reflect reduction in gravitational attraction in proportion to distance between spacecraft and solar system. Only five eighth part of 'central force' is utilised for spacecraft's acceleration towards solar system. Rest, three eighth part of 'central force', is used to spin

spacecraft about an axis perpendicular to its orbital plane [1]. Radial speed of spacecraft, towards solar system is combined with absolute linear speed to get its resultant speed in space. Magnitude of resultant speed depends not only on magnitudes of constituent speeds but also on angular difference between them.

Anomalies in parameters of Pioneer spacecrafts were noticed, when they were more than 20 au farther from boundaries of solar system. As this distance is too large compared to distribution of large macro bodies in solar system, it is convenient to assume whole of solar system's matter-content is concentrated at the centre of sun. Sun travels in circular path around galactic centre. Since period considered is too small (less than 100 years) compared to time required for sun to travel through one full circle, we may consider sun's path (a small part of circular path) as a straight line. Distance, between observer on earth and spacecraft may be taken as distance between spacecraft and centre of sun.

Figure 3 represents general layout of a planetary system that has solar system (represented by sun) as central body and a spacecraft (leaving solar system) as its planetary body. Blue arrow XX shows linear path of sun (small part of its curved path). A is one of its past position, C is one of its future position and B is its current position. a, b and c are positions of spacecraft corresponding to positions A, B and C of sun. Curve SS in red dashed line shows part of apparent orbital path of spacecraft, corresponding to current position of sun at B and spacecraft at b. Line TT in red shows tangent at point b to apparent orbit SS.

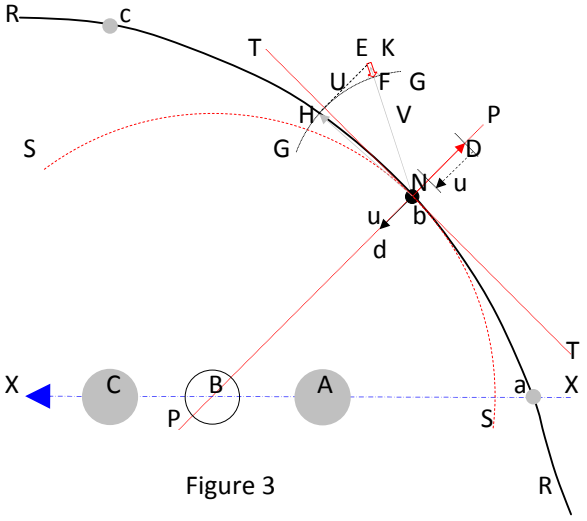

Figure 3

Considering motion of spacecraft in relation to its apparent orbital path; it is situated at b on its apparent orbital path SS. It has radial velocity, u, represented by arrow bd towards sun. At the same time, spacecraft is moving away from sun, under centrifugal action (provided by outward deflection of its linear motion). Magnitude of spacecraft's outward deflection is represented by red arrow bD. bD = EH. Taking resultant of these two motions (in opposite directions), spacecraft has resultant (rate of) outward displacement equal to bN, away from sun. As distance between sun and spacecraft increases, magnitude of gravitational attraction between them and hence spacecraft's radial velocity towards sun decreases. As long as spacecraft's outward displacement is more than its radial displacement due to gravitational attraction towards sun, it should continue to move away from solar system at a rate corresponding to resultant of inward and outward velocities. However, in the case of pioneer spacecrafts, their inward velocity appeared to over-compensate and effectively reduce its outward velocity. This brings about an unaccounted apparent radial acceleration towards sun.

Calculations to determine parameters of spacecraft's motion, on these bases, do not allow any discrepancy in magnitudes of its displacements. Ultimately, spacecraft may enter into stable apparent orbit around sun, unless outward impetus that drives it away from sun lasts until gravitational attraction between the two has become negligible. Even today, Pioneer spacecraft is under influence of gravitational attraction towards sun. However, magnitude of gravitational attraction is not sufficient to move it along stable orbital path. As long as this state of affairs continues, apparent orbit of spacecraft around sun gradually enlarges to take it away from sun. Parameters of its motion always adhere to calculations, made in this regard. Nevertheless, a discrepancy is noticed in distances from sun, determined by direct observation. Spacecraft is found nearer to sun than distance determined by calculation and this discrepancy is termed as 'Pioneer anomaly'. In reality, there is neither an external effort on spacecraft nor does it have any additional acceleration towards central body. Additional reduction (not corresponding to calculation) in linear speed of spacecraft is assumed as a result of unaccounted inward acceleration.

When displacement of spacecraft is determined as per current laws on planetary motion, it is assumed to move in apparent elliptical orbital path around central body. Its present instantaneous linear speed and its future instantaneous linear speeds are approximately equal. As spacecraft moves away from central body, its apparent orbital path expands at a steady rate. This means that spacecraft should be moving away from central body at certain linear speed.

However, by considering real orbital path of spacecraft, as shown above with respect to figure 3, in order to move away from central body, present instantaneous linear speed, bE, of spacecraft is maintained slightly greater than its future instantaneous linear speed, bH. Difference in these linear speeds is not accounted, when apparent orbital path is used. Excess magnitude, EF, of present instantaneous linear speed over future instantaneous linear speed appears only when we consider real orbital path of spacecraft. Future instantaneous linear speed is always less than present instantaneous linear speed of spacecraft. This difference reflects in displacement of spacecraft from central body. Real distance travelled by spacecraft, determined by using future instantaneous linear speed, is less than apparent distance, determined by using present instantaneous linear speed.

As the spacecraft has not travelled by apparent distance, determined by present instantaneous linear speed, discrepancy is assigned to various phantom phenomena that may produce additional retardation of spacecraft in its motion, away from central body. This difference appears as a result of an unknown acceleration towards sun and causes 'pioneer anomaly'.

Magnitude of reduction in spacecraft's absolute linear speed depends also on its position with respect to sun, in the first/third quarter of its real orbital path. Hence, magnitude of anomaly depends on relative positions of sun and spacecraft in their real orbital paths. It is variable.

In the case of apparent orbits, inward radial velocity of a planetary body, due to mutual gravitational attraction, is assumed to act always perpendicular to planetary body's linear motion. Linear motion of planetary body is assumed along tangents to apparent orbits. Changes in distance between central and planetary bodies are affected only by deflection of direction of planetary body's linear motion. In case of real orbital paths, depending on relative positions of planetary and central bodies, angle between absolute linear motion of planetary body and its radial velocity towards central body changes through full circle. Absolute linear motion of planetary body is taken in its true direction, in space. Therefore, a component of radial inward motion directly reduces planetary body's absolute linear motion, in addition to, deflection of planetary body's direction of absolute linear motion. This additional reduction in absolute linear speed of spacecraft accounts for discrepancies, currently noticed as 'pioneer anomaly'.

Conclusion:

'Pioneer anomaly' is the result of using geometry of apparent orbital path of spacecraft around solar system instead of geometry of its real orbital path (in space) about solar system. Additional retardation to absolute linear motion of planetary body, as seen in real orbital motion of a planetary body in certain parts of its real orbital path, can account for this anomaly.

Reference:

[1] Nainan K. Varghese: *MATTER (Re-examined)*, http://www.matterdoc.info

* ** *** ** *