# FLYBY ANOMALY

(According to "*Hypothesis on* MATTER")

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*Abstract:* 'Flyby anomaly' is a significant but unaccounted apparent increase or reduction in the velocity of a spacecraft during Earth-flybys. These phenomena could not be explained by current physical laws. This article attempts to show that the noticed discrepancies are apparent and they are produced by faulty geometry used in contemporary laws of planetary motion. In reality, the spacecrafts and external efforts on them behave normally. There are no causes or actions, which vary a spacecraft's linear velocity during Earth-flybys. There is no basis for assumption of strange 'forces' or mysterious effects on or about these spacecrafts.

*Keywords:* Flyby anomaly, swing-by anomaly, planetary orbits, Hypothesis on MATTER.

## Introduction:

Spacecrafts, whose velocities are boosted by gravitational assistance (sling-shot effect) in conjunction with earth, are sometimes noticed to have gained or lost certain (very small) part of their calculated velocity. These unaccounted changes in the velocity of a spacecraft (currently measured up to 13.5 mm/s) during Earth-flybys are called 'flyby anomaly' or 'swing-by anomaly'. It seems to occur at varying magnitudes to arbitrary satellites during random flybys. This phenomenon gave rise to numerous speculations and exotic theories. However, none of them could, so far, logically explain the anomaly, satisfactorily. As in the case if 'pioneer anomaly' [7], 'flyby anomaly' is an apparent error introduced by the use of apparent orbital paths of spacecrafts around their central body (earth) and apparent orbital path of earth around sun, in calculations, instead of their real orbital paths in space.

### Hypothesis on MATTER:

'Hypothesis on MATTER' [1] is an alternative concept that logically explains all physical phenomena. It is based on a single type of postulated matter particle – the quanta of matter. No other postulated entities or properties are used in this concept. Everything else in the universe is developed from quanta of matter and all properties are continuation of inherent property of quanta of matter. Development of this concept proposes a universal medium (made up of real matter) that can provide an absolute reference for all actions in nature [3]. In complete sense, all actions can be fully understood only in terms of their absolute nature. This concept does away with 'actions at a distance through empty space' and shows that all 'natural forces' are fundamentally the same. It follows strict 'cause and effect' relations in all explanations.

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, these laws can be true only to determine relative positions of macro bodies in a planetary system with respect to their central body. Using these laws to determine other parameters of macro bodies in the solar system or their orbital characteristics is not right. Relative positions of a planetary body, moving in stable (real) orbital path about a central body may be predicted by contemporary laws of planetary motion.

All conclusions, expressed in this article, are from the '*Hypothesis on* MATTER' [1]. For details, kindly refer to the same. Figures are not drawn to scale. They are depicted only to facilitate 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. Simultaneously, simple mechanics tells us that no free macro body can orbit around another moving free macro body in a closed geometrical path. Elliptical (or circular) orbital path, around a central body, is an apparent structure that suits observation by an observer on a static central body. This is not the real path of a 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 spinning galaxies may remain stationary in space) [1]. With respect to an absolute reference, a planetary body does not orbit around its central body. Real orbital path of a planetary body's motion (about its central body) is wave-like, along central body's path, with the planet periodically moving to the front and to the rear of the central body, as shown in figure 1. A brief description on true orbital motion may be found in article 'Planetary orbits' [4] at http://vixra.org/abs/1008.0010. In this article, we shall ignore eccentricity of apparent planetary orbits and consider them as circular.

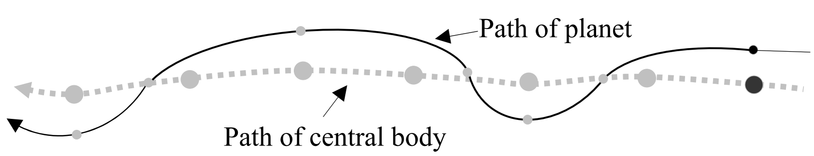


Figure 1

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

Figure 2, compares between real and apparent orbital paths of a planetary body. Blue arrow in the centre of figure 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. Large grey circles show future and past positions of the central body. Planetary body is shown in its present position by small black circle and grey small circles show planetary body's future positions. Real orbital path of the planetary body is shown by black curved line with an arrow in the direction of its motion. This may be divided into four quarters as shown separated in the figure by vertical dotted lines. Unevenness in the width of quarters is due to different scales, used in the figure for vertical and horizontal measurements. Large circle in dashed red line shows apparent orbit of planetary body around the central body, in its present position. This apparent orbit travels along with central body in its path. Apparent orbit shows an imaginary path around the central body on which every point is equidistant from central body (for circular apparent orbit). In order to obtain an apparent orbital path, we need to split the real orbital path into two curved paths, one on

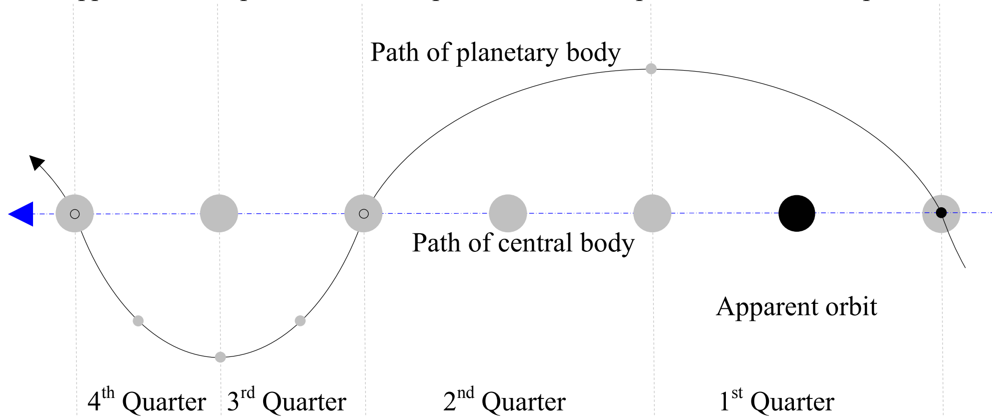


Figure 2

either side of central body's path and recombine them by changing direction of planetary body's motion in one of the curved path. Apparent orbital path gives accurate information on relative positions of central and planetary bodies and no other orbital parameters.

'Hypothesis on MATTER' stipulates that;

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

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

All planetary bodies enter into orbital path from external space. Entry of a planetary body 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 planetary body has an ideal 'datum orbital path' about its central body. Datum orbital path is a circular apparent orbit around a central body, assumed in static state. Parameters of a datum orbital path depend on masses (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 a small conical window in space, on datum orbit, facing to the rear on the outer (convex) side of linear path of central body.

Five eighth part of 'central force' on a planetary body is utilised for its orbital motion and the rest, three eighth part of 'central force' is utilised for its spin motion. [5 and 6].

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

## Spacecraft's orbital path about earth:

Figure 3 shows representations of paths of sun, earth and a spacecraft orbiting about the earth. Central line with an arrow shows a small part of sun's path around galactic centre. A small part of sun's circular path around galactic centre is considered as a straight line-path. Sun moves in the direction of black arrow. Galactic centre is towards lower side of the figure 3. Sun's mother-galaxy is considered as rotating in anti-clockwise direction, looking down at the page.

Dashed curves (blue and red) on both sides of sun's path show earth's real orbital path about the sun, which is equivalent to earth's one apparent orbital path around the sun. Apparent orbit of earth is considered here as circular, with sun at its centre. Large difference in curvatures of these curved paths, on either side of sun's path, appearing in the figure 3 is due to very small horizontal scale used in the figure, compared to vertical scale used. In reality they are almost of the same size and curvature.

Bold wavy line (blue and red) about earth's real orbital path shows real orbital path of a spacecraft, orbiting about the earth. Due to difference in lengths of curves representing earth's orbital path, as appearing in the figure, numbers of spacecraft's apparent orbits during every half-apparent orbit of earth are shown in the figure are different (14 on outer side and 7½ on inner side). In reality numbers of apparent orbits of spacecraft during every half-apparent orbit of earth are same (in this case 14 each).

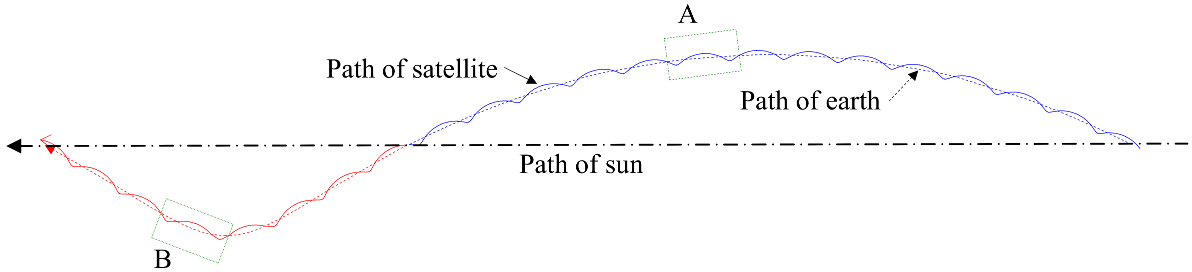


Figure 3

Spacecraft moves along with earth, which moves along with the sun. In effect, the sun, earth and the spacecraft move together around galactic centre. Stable galaxies have special mechanism to keep them in space without translational motion, with respect to neighboring galaxies [1].

Parts of real orbital paths of earth and spacecrafts, marked by rectangles A and B, are taken for comparison in figure 4. Rectangle A is on the outer side of sun's real path and rectangle B is on the inner side of sun's real path about sun's circular path in space.

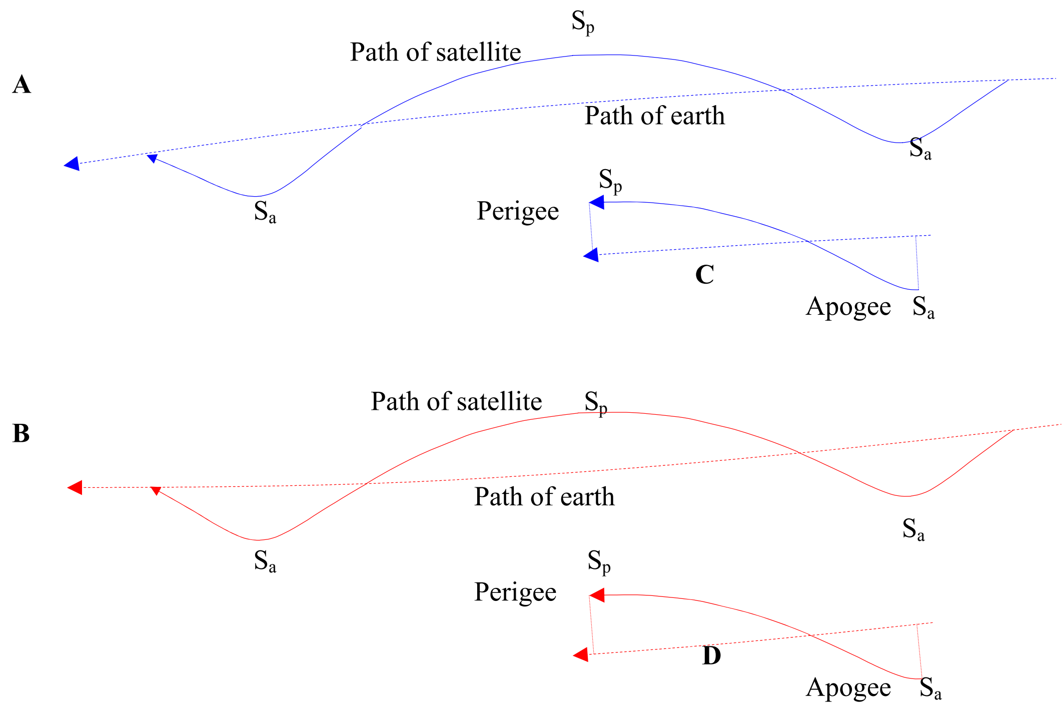


Figure 4

Figure 4 shows enlarged views of real orbital paths of earth and spacecraft in space marked by rectangles A and B in figure 3. Part A of figure 4 (blue) shows real orbital paths on the outer side of sun's real path and Part B of figure 4 (red) show real orbital paths on the inner side of sun's real path in space. Dashed lines with arrow show parts of earth's real orbital path about sun. Bold lines (red and blue) with arrows show spacecraft's real orbital path about earth's real orbital path. On spacecraft's path, point, $S_p$, shows 'outer datum point' and point, $S_a$, shows 'inner datum point' [4] on its datum orbit. ['Outer datum point' on real orbital path of a planetary body is where it has highest (absolute) linear velocity and 'inner datum point' on real orbital path of a planetary body is where it has lowest (absolute) linear velocity. These points need not coincide with perigee or apogee of its apparent (elliptical) orbit around the central body].

Whenever, curvatures of real orbital paths of both, the earth and the spacecraft, are in the same sense, they tend to come closer and thus reduce distance between earth and the spacecraft. Whenever curvatures of real orbital paths of both, the earth and the spacecraft, are in opposite sense, they tend to move farther and thus increase distance between earth and the spacecraft.

When earth is traveling on outer side of sun's circular path;

During spacecraft's travel on outer side of earth's real orbital path, part A of figure 4, real orbital paths of both, the earth and the spacecraft, have curvatures in the same sense. During spacecraft's travel on inner side of earth's real orbital path, part A of figure 4, real orbital paths of both, the earth and the spacecraft, have curvatures in opposite sense.

When earth is traveling on inner side of sun's circular path;

During spacecraft's travel on outer side of earth's real orbital path, part B of figure 4, real orbital paths of both, the earth and the spacecraft, have curvatures in the same sense. During spacecraft's travel on inner side of earth's real orbital path, part B of figure 4, real orbital paths of both, the earth and the spacecraft, have curvatures in opposite sense.

Gravitational attraction between spacecraft and earth, accelerates the spacecraft during its travel from its 'inner datum point', $S_a$, to 'outer datum point', $S_p$. Gravitational attraction between spacecraft and earth, decelerates the spacecraft during its travel from its 'outer datum point', $S_p$, to 'inner datum point', $S_a$,. Gravitational assisted boosting of spacecraft's velocity takes place during its travel from its 'inner datum point', $S_a$, to 'outer datum point', $S_p$. Parts C and D, in figure 4, show accelerating parts of spacecraft's real orbital path with corresponding parts of earth's real orbital path.

Part C of figure 4 (in blue) represents part of earth's real orbital path and part of spacecraft's real orbital path, on the outer side of earth's real orbital path. Earth's real orbital path has a small convex (pointing upwards in the figure) curvature. Part D of figure 4 (in red) represents part of earth's real orbital path and part of spacecraft's real orbital path, on the inner side of earth's real orbital path. Earth's real orbital path has a small convex (pointing downwards in the figure) curvature.

For comparison, real orbital paths of earth and spacecraft, for duration of spacecraft's on apparent orbit from parts A and B in figure 4 are super-positioned on each other in figure 5. Parts of spacecraft's real orbital path, on either side of earth's real orbital path are shown in equal sale. Hence, magnitudes of their departure from earth's real orbital paths, in figure 5, appear almost similar. Curvatures of parts of earth's real path, shown in dashed (blue and red) lines, are highly exaggerated. Figure 5 shows real orbital path of a spacecraft about earth, equivalent to one apparent circular orbital path around earth.  Red curved lines (part B) show real paths of earth and spacecraft, during earth's motion on the inner side of sun's path. Blue curved lines (part A) show real paths of earth and spacecraft, during earth's motion on the outer side of sun's path.

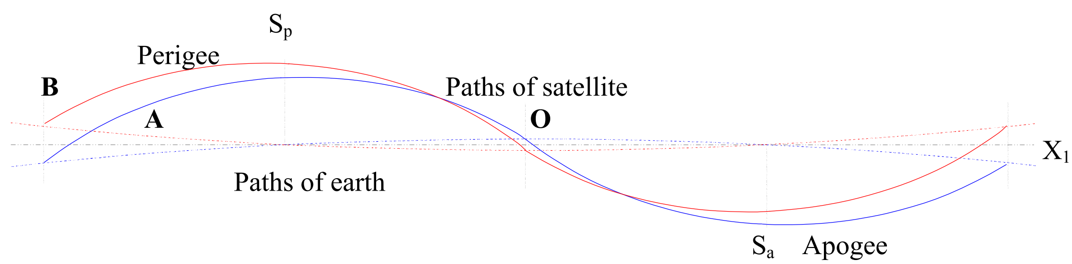

Figure 5

We always consider apparent orbital paths of celestial bodies for all practical purposes. Since apparent orbital paths are built up from observed relative positions of various celestial bodies in space, they can only give relative positions of celestial bodies at any time. Any other parameter derived from apparent orbit of a planetary body will not be its true parameter. In this case, apparent path of earth, with respect to spacecraft's path, is generally considered as (an average) straight-line path, shown by central line $X_1X_2$.

For following explanations, we shall consider real orbital paths of a spacecraft that is orbiting about the earth and keeps a constant distance between the two. Distances between earth and spacecraft at its perigee, $S_p$, and at its apogee, $S_a$, are equal. Spacecraft accelerates, due to gravitational attraction, during its travel from apogee to perigee. Spacecraft decelerates, due to gravitational attraction, during its travel from perigee to apogee. (Part of) 'central force', simultaneously, provides the spacecraft with constant radial acceleration and constant radial velocity towards earth. Inward radial velocity of the spacecraft is nullified by outward component of spacecraft's present (absolute) linear speed [5]. In this case, apparent orbit of spacecraft is circular around earth. Spacecraft keeps constant distance from earth. The spacecraft has no linear acceleration or deceleration in its apparent orbital path. Its linear speed, along apparent orbital path is of constant magnitude. 'Central force' is assumed to provide only radial acceleration, which is nullified by an illusory acceleration provided by imaginary 'centrifugal force' in opposite direction.

Figure 6 show part of earth's real orbital path, in blue dashed curve, when earth is moving on the outer side of sun's path and part of earth's real orbital path, in red dashed curve, when earth is moving on the inner side of sun's path. Corresponding parts of spacecraft's real orbital path, during its accelerating stages due to gravitational attraction towards earth, are shown in blue (when earth is moving on the outer side of sun's path) and red (when earth is moving on the inner side of sun's path) bold curves. Sets of corresponding paths are super-positioned to highlight their relative differences.

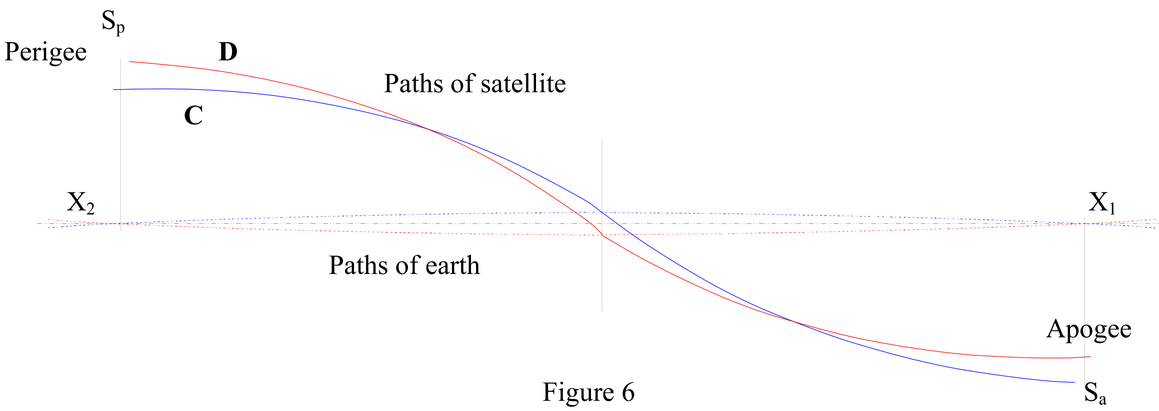


Figure 6

When apparent orbits of a spacecraft are considered as circular, distance between spacecraft and earth is assumed to be of constant magnitude. However, considering real orbital path of spacecraft (corresponding to circular apparent orbit) about the earth, distances between earth and spacecraft do not remain constant. They differ as shown in the figure 6. Average distances between spacecraft and earth, at different points on spacecraft's apparent orbital path are average distances at corresponding points on its real orbital paths with respect to various locations of earth on its real orbital path.

When earth is in its real orbital path, outside sun's path (shown in blue dashed curve), distance between earth and spacecraft (which has circular apparent orbital path) at $S_p$ (at perigee) is less than the distance between earth and the spacecraft at $S_a$ (at apogee). Similarly, when earth is in its real orbital path, inside sun's path (shown in red dashed curve), distance between earth and the spacecraft (which has circular apparent orbital path) at $S_p$ (at perigee) is more than the distance between earth and the spacecraft at $S_a$ (at apogee). Magnitudes of differences depend on curvatures of earth's real orbital path, at any given point. If shape of apparent orbital path differs from being circular (elliptical), differences in distances between spacecraft and earth will also change correspondingly. Since we consider apparent orbits of spacecrafts around earth, for all practical purposes, these differences do not appear in our assessment.

Regular and cyclic variations in distances between earth and an orbiting (in circular apparent orbit) spacecraft, explained above, are due to curvature of earth's real orbital path. Curvature of earth's real orbital path is produced by perturbations, mainly due to gravitational attraction between earth and sun. Since, perturbations of spacecraft's real orbital path, due to gravitational attraction between spacecraft and sun (although very small) are of the same sense; they augment variations in distances between earth and spacecraft. Similar perturbations due to presence of other celestial bodies (especially moon) may also contribute towards variations in instantaneous distances between spacecraft and earth.

In an apparent orbit, perigee and apogee are the only two points at which conditions for circular apparent orbital paths are fulfilled [4]. At these points, the condition;

$$W = 2\mathrm{Sin}^{-1}\frac{u}{2V}$$

(where, W is deflection rate of angle between present absolute linear speed and future absolute linear speed of planetary body, u is magnitude of radial velocity of planetary body towards its central body and V is magnitude of present absolute velocity of planetary body) is satisfied. At these points, magnitude of 'drifting rate' (the rate of change of angle between direction of present absolute linear speed and tangent to apparent orbit) is half of 'deflection rate', W. For details, please refer to reference [4].

Hence, it is at either of these points, orbital motion of a planetary body (in stable apparent orbit) can breakdown. Depending upon the magnitude of 'central force', a planetary body may choose to maintain its orbital motion, fly away from central body or fall into central body [1]. To form a stable real orbital motion about a central body, a planetary body has to have its 'drifting rate', between $\mathrm{Sin}^{-1}(u \div 2V)$ and $-\mathrm{Sin}^{-1}(u \div 2V)$, at perigee or apogee of its apparent orbit. For variations in magnitude of 'central force' within certain limits [4], planetary body will be able to maintain its orbital motion. Excess magnitude of linear speed (caused by higher magnitude of radial acceleration during accelerating stage) will drive the planetary body, away from central body, as is in the case of Earth-flybys. Shortage in magnitude of linear speed (caused by higher magnitude of radial deceleration during decelerating stage) will drive the planetary body towards its central body to fall into.

Estimations of orbital parameters are always approximate and vary continuously. Orbital parameters may best be estimated to nearest average magnitudes. Variations or discrepancies of orbital parameter, thus determined, are usually attributed to assumed properties, like; tidal effects, inconsistency of earth's matter body, frame dragging, rotary motions of bodies, effects of other celestial bodies, anomalous Doppler effects, effects of dark matter, etc. These in turn, helps to produce exotic theories about physical phenomena. However, real orbital paths of corresponding bodies are never considered. As we require average values of these parameters for all practical purposes, changes in real orbital paths or cyclic changes in distance between earth and spacecraft do not make much difference, when continuous orbital motions of spacecrafts are considered. Discrepancies develop into prominence only when spacecrafts are diverted away from their (regular) orbital path about earth.

Real orbital path of a spacecraft about earth depends on its orbital parameters. Real orbital parameters of a spacecraft may be manipulated to move the spacecraft in any desirable apparent orbital path, by external influences. Should magnitudes of variations in real orbital parameters may exceed values required for their desirable apparent orbital motion, real orbits of spacecrafts may become unstable and cause the spacecraft to fly away from earth or fall into earth. From the instant of instability that terminates a spacecraft's orbital motion, average orbital parameters, estimated for apparent orbital motion are no more valid. Correct estimations will depend of real orbital parameters of spacecraft at the instant of instability. Result may be (slightly) different from average parameters estimated for continuous orbital motion. It is this type of difference in estimation of orbital parameters that causes 'flyby anomaly'.

## Flyby anomaly:

Usually, orbital parameters of a planetary body (or a spacecraft), except angular orbital speed with respect to earth, are estimated from mathematical relations based on various assumptions used in physics, like; a central body is static in space, a planetary body orbits around its central body (in closed geometrical path), a planetary body has highest linear and angular speeds at perigee, a planetary body has lowest linear and angular speeds at apogee, matter content of a macro body is concentrated at a point (centre of gravity), distance between two macro bodies is between their centres of gravity, etc. Angular orbital speed with respect to earth can be easily measured by instruments on the surface of earth and corrected for various motions of earth. Another exemption is that of distance between earth and moon, which we are able to measure accurately with the help of 'laser rays' and reflectors placed on moon's surface, recently. Even in this case, due to various continuous motions of earth and moon, measured distance is valid for only for the instant of measurement. Apparent orbital path of a spacecraft, which is capable to supply only its relative position [4], is used to estimate all its other orbital parameters.

Estimates of orbital parameters of a spacecraft are based on (Newton's) 'laws of motion' and 'laws of universal gravitation'. Linear velocity of a spacecraft is estimated from mathematical equations constituted by its orbital angular speed about earth, gravitational attraction towards earth, radii of earth and spacecraft, distance between earth and spacecraft, mass of earth (representing its matter content), etc. Changes or discrepancy in any one of these factors is bound to introduce errors in estimation of all other parameters.

In the case of a spacecraft, its instantaneous linear speed is determined from its observed angular orbital speed (usually, at perigee or at apogee) and distance between earth and spacecraft. In circular apparent orbit, distance between spacecraft and earth is assumed to be of constant magnitude. Hence, any variation in spacecraft's observed angular orbital speed is attributed to a change in its linear orbital speed. Logically, in order to change linear orbital speed of a spacecraft, it has to be decelerated or accelerated. If no external effort is known to decelerate or accelerate the spacecraft, this anomalous phenomenon is becomes a mystery. It then becomes fertile ground for speculations and exotic theories. If only we would consider accuracy of the assumption of constancy of distance between spacecraft (moving in circular apparent orbit) and earth, this mystery could be avoided.

For the same magnitude of linear orbital speed, greater distance will produce lower angular orbital speed and smaller distance will produce higher angular orbital speed. If variations in distances are not acknowledged, changes in angular orbital speeds are obviously attributed to changes in linear orbital speeds. This would certainly require linear acceleration/deceleration of the spacecraft and corresponding external influence on it.

Explanations in previous section shows that if real orbital path of a planetary body is considered, distance between centre and planetary bodies (even for circular apparent orbital motions) vary continuously, within certain limits. Since these changes are cyclic, they do not appear distinctly during average considerations. However, when instantaneous parameters are determined, they do make divergences from average values.

In figure 7, let the central body (earth) be at O. Let $Or_0$ be average distance between earth and a spacecraft, moving in circular apparent orbit about earth. $\omega_0$ is the angular orbital speed of spacecraft, observed from earth. $Br_0 = \omega_0 r_0$ is the estimated linear orbital speed of spacecraft.

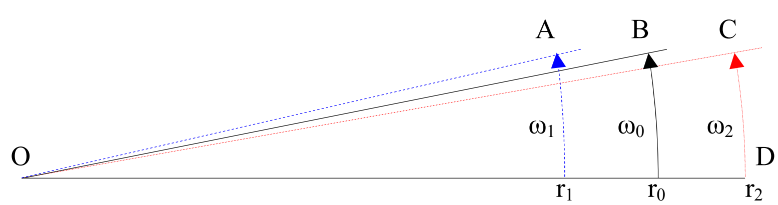


Figure 7

When instantaneous conditions are considered, in terms of real orbital path of spacecraft about the earth, distances between earth and spacecraft (even for circular apparent orbital motions), vary continuously. When earth is on the outer side of sun's path and spacecraft is on the outer side of earth's path, distances between spacecraft and earth are less than, when earth is on the outer side of sun's path and spacecraft is on the inner side of earth's path. Similarly, when earth is on the inner side of sun's path and spacecraft is on the outer side of earth's path, distances between spacecraft and earth are less than, when earth is on the inner side of sun's path and spacecraft is on the inner side of earth's path.

Let us take two other instances, where distances between earth and spacecraft are $Or_1$ and $Or_2$. Let the spacecraft move at constant linear orbital speed, $Ar_1 = Br_0 = Cr_2$. When the spacecraft is a distance $Or_1$, angular orbital speed observed from earth, is $\omega_1$. This is greater than $\omega_0$. If reduction in distance is not taken into consideration, greater angular speed would indicate an apparent increase in spacecraft's linear speed, without logical causes. When the spacecraft is a distance $Or_2$, angular orbital speed observed from earth, is $\omega_2$. This is lesser than $\omega_0$. If increase in distance is not taken into consideration, smaller angular speed would indicate an apparent reduction in spacecraft's linear speed, without logical causes.

Variations in distances between earth and spacecraft, at different locations in its real orbital path are reflected in its angular orbital speed, observed from earth. Hence, magnitude and sense of apparent change in spacecraft's linear speed, on its release from orbital bond with earth, depends on locations of spacecraft and earth in their respective real orbital paths. Hence, depending on locations of earth and spacecrafts in their real orbital paths, apparent variations in spacecraft's linear speed may vary in magnitude and sense.

Explanations in this article are with respect to a spacecraft destined to move in circular apparent orbit, where distance between earth and spacecraft is assumed to be of constant magnitude. If destined apparent orbit of spacecraft is elliptical, eccentricity of elliptical apparent orbit is bound to make additional variations in orbital parameters of the spacecraft.

## Conclusion:

Depending on locations of spacecraft and earth in their respective real orbital path, at the instant of its release from orbital bond, a spacecraft's linear speed could apparently increase or decrease, without external causes. This phenomenon is quite logical and there is no mystery about it. There are no puzzling actions or anomalous effects. There is no increase or reduction in (kinetic) energy, associated with the spacecraft. Although, apparent acceleration/deceleration is indicated by 'flyby anomaly', spacecraft's linear speed (in space) hardly varies. Therefore, 'flyby anomaly' is a phantom phenomenon, caused by incorrect use of orbital geometry of apparent orbital path of spacecraft around earth instead of geometry of its real orbital path (in space) about earth.

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References (except [8]) are self-published by the author. They are neither reviewed nor edited.

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