

# PLANETARY ORBITS

(According to “Hypothesis on MATTER”)

Nainan K. Varghese, matterdoc@gmail.com

*Abstract:* Due to constant motions of free bodies, it is practically impossible for a free body to orbit around another. However, they may orbit about each other and follow a common median path in space. Such motion, when viewed from a planet appears to be its orbital motion around the central body. This is merely an illusion created by the relative motions of the bodies. Changing inertial frames and arbitrary changes in the direction of motion, during mathematical operations, help to bring their results in line with observations. Taking this apparent orbital motion as a scientific fact and applying it to prove the validity of “laws of gravitation” is illogical. Mechanism of orbit-formation and the limitations of orbiting bodies described in this article are based on a radically different dynamics from an alternative concept put forward in “Hypothesis on MATTER”. A planet’s parameters, during initial entry into its datum orbit, determine the size and eccentricity of its apparent orbit. Only those bodies, which approach the central body from the rear, on the outer side of its curved path, through a small window in space can form stable orbits. Hence, it is imperative that all bodies of a planetary system orbit in the same sense and are (almost) in the same plane. Perihelion/aphelion of an orbital path could be anywhere in the orbit, but the point at which the orbiting body has its highest/lowest linear speeds are fixed in relation to the central body’s path. All natural planets, whose perihelion are in front of their point of entry; arrive from outside the planetary system. Since the effects of bodies, outside a planetary system, on the parameters of central and planetary bodies are (almost) identical, such effects are negligible. Effects of other bodies, within a planetary system, on the parameters of central and planetary bodies are neglected in this article.

*Keywords:* Orbits, Orbital mechanism, Central force, Planetary orbits, Solar system, Celestial mechanism, Astronomy, Cosmology, Hypothesis on MATTER.

---

## Introduction:

“Hypothesis on MATTER” describes an alternative concept. In it: Whole matter in the universe is the form of quanta of matter. Matter content of a body and the energy about it are distinctly separate. Matter content is the total sum of three-dimensional matter in a body. Energy is the strain developed due to ‘distortions’ in the natural arrangements of basic matter particles in and about a body. Matter content and energy content of a body cause and support each other for their existence and stability. They are not convertible into each other. Entire space is filled with ‘2D energy fields’, two-dimensional latticework formations by basic 1D quanta of matter. 2D energy fields, in various directions and planes, passing through a point, co-exist. Although, 2D energy fields are made of (apparently) rigid quanta of matter, it has all properties of an ideal liquid. Parts of 2D energy fields, within the macro-body-dimensions, contain sufficient distortions to sustain integrity and stability of a macro body in its current state. This part of 2D energy fields is the ‘matter field’ of the body. Distortions in the matter field are the ‘work-done’ existing in the body and it determines the state of (motion of) the body. Force is the rate of work being stored in a macro body with respect to rate of its displacement. Action of an effort is simple structural reshaping of the matter field and the resulting motion of any matter particles present in the region. State of (motion of) a body depends on the work (energy stored) in it rather than on the effort applied on it. All apparent interactions between matter bodies take place through the medium of 2D energy fields. This avoids the assumption of ‘actions at a distance’. There are no ‘pull forces’ or ‘rigid bodies’ in this concept. All forces, classified into various types, are different manifestations of ‘only one type of force’ and it is of ‘push nature’. Work is transmitted only in straight lines and separately in each plane. Forces in different planes do not form a resultant. Forces in the same plane in different directions interfere to reduce/increase each other’s efficiency to produce the body’s motion. Independent displacements of a body, produced by external efforts in different directions or in different planes may be regarded, together, to be resultant motion of the body in 3D space system. In this article, present conventions of ‘pull forces’ and their resultants are used for clarity. A free body is that macro body, which is free from all interferences other than the forces/actions considered. Although a force can exist only when there is a related (body’s) acceleration, in this article, the term ‘force’ is often used in its conventional sense to represent an effort.

Tendency of a 2D energy field to attain serenity does not allow static distortions in it. Transfer of distortions in the matter field of a macro body carries the associated matter particles and thus produces body’s motion. This inertial action, about a macro body, maintains its state (of motion). A change in the inertial actions about a macro body produces its acceleration. If certain work is invested into or removed from a body, the body will attain a stable state only after inertial delay, during which the work within the body stabilizes. This is true even after the action of effort is terminated. Matter is inert; it has no ability to move or act on its own. Associated matter field-distortions of a macro body produce all apparent actions, presently assigned to the matter (bodies).

Presence of 3D matter particles in a 2D energy field breaks its continuity. Discontinuity causes imbalance in the 2D energy field. Pressures applied by the 2D energy field latticework from the sides, in an attempt to restore its continuity, compress a matter particle. [Basic 3D matter particles are of uniform radial size and they constitute all other superior matter bodies]. If the extents of 2D energy field on opposite sides of a matter particle are unequal, the matter particle experiences a resultant effort, which tends to move the particle towards the side of lower effort (pressure or force). Extent of 2D energy fields between two matter particles is always less than the extent of 2D energy fields on their outer sides. As a result, matter particles are pushed towards each other. Motions of constituent particles move the whole body. This action gives rise to the apparent gravitational attraction between bodies. Apparent gravitational attraction between two bodies is, relatively, a minor by-product of gravitational actions. It takes place between (spinning and disc shaped) basic 3D matter particles of both the macro bodies, which are in the same plane at the given instant. Apparent gravitational

attraction, at any instant, is produced between extremely small numbers of basic 3D matter particles in two macro bodies. An average apparent attraction is derived from sporadic actions between various matter particles, which happen to be in the same plane at any instant. Contrary to present belief, gravitational action is enormously strong compared to other manifestations of efforts (forces). All conclusions expressed in this article are taken from the “*Hypothesis on MATTER*” [1]. For details, kindly refer to the same.

### Linear motion of a rotating body:

Linear and rotary motions of a body are entirely separate. Each of them is produced by separate set of work-done on the body. However, each point on a linearly moving rotating body has its own path of resultant motion. Its motion and the path appear to be resultant of the linear and rotary motions of the body. In figure 1, ‘A’ shows a rotating body that has no linear motion. Centre point of the body ‘O’ may be assumed steady in space. Point P on its periphery traces a circular path, as shown by the circle in dashed line. Let the body develop a linear motion, as is shown by ‘B’ in the figure 1 and its centre of rotation moves from  $O_1$  to  $O_2$  at a constant speed, while the body turns through one revolution. Point  $P_1$  on its periphery traces a loop as shown by the black curved line starting from  $P_1$  and ending at  $P_2$ .

‘C’ in figure 1 shows the rotating body moving at a higher linear speed. Centre of rotation of the body moves linearly through a larger distance from  $O_1$  to  $O_2$ , while the body turns through one revolution. Loop traced by a peripheral point becomes narrower as the linear speed increases, for the same rotary speed. ‘C’ shows the path of the peripheral point during one rotation of the body. Continuous loops in black from  $P_1$  to  $P_n$  in ‘D’ shows a continues path traced by the peripheral point in space, while the centre of rotation of the rotating body moves linearly from  $O_1$  to  $O_n$  along the line

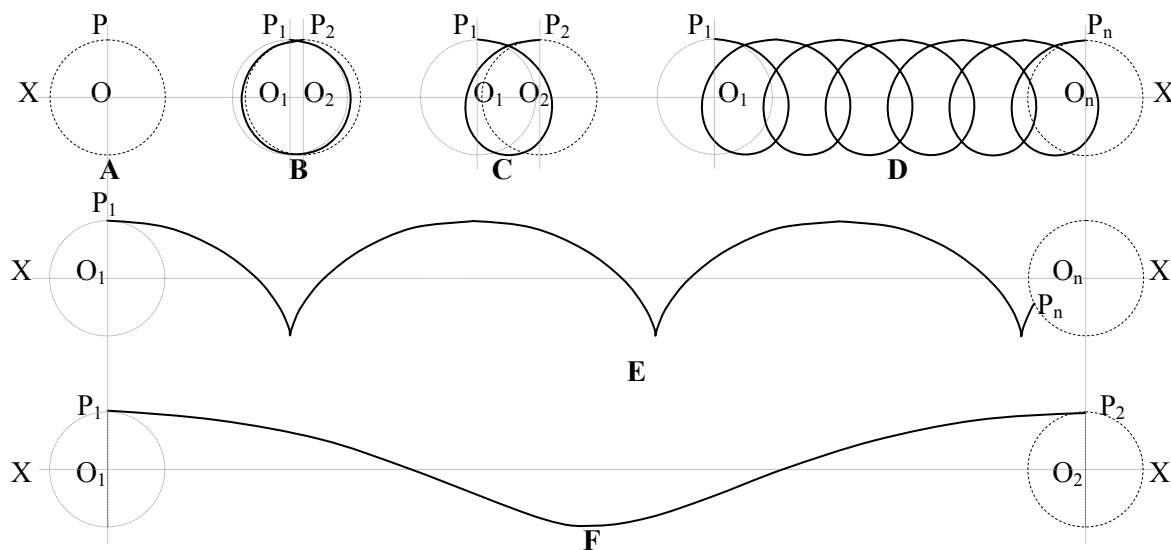


Figure 1

XX. As the linear speed of the body increases in relation to its rotary speed, the loops in the path of the peripheral point gradually becomes narrower until the loops altogether disappear at a stage. At this stage, the body’s linear speed equals  $\pi$  times the radius of the rotating body (distance of the peripheral point from the centre of rotation of the body) during every rotation of the body. Black series of semi-circular paths ‘E’ in figure 1 shows the curved path traced by a peripheral point. Resultant path of the peripheral point consists of semi-circular curves with their convex sides in the

same direction. The path starts from  $P_1$  to  $P_n$  in 'E', while the centre of rotation of the rotating body moves linearly from  $O_1$  to  $O_n$  along the line XX. As the linear speed of the body exceeds this value, all points in the body have no motions in the reverse linear direction. All points in the body have displacements only in the forward direction. The requirements that points in the body on opposite sides of centre of rotation have motion in opposite directions are no more satisfied. No point in the body has circular/elliptical path in space. All points in the body move in forward linear direction only. However, with respect to any point in the body, all other points in its plane of rotation, appears to move in circular path around the point of reference.

As the linear speed of the rotating body is increased, circular path of the peripheral point expands to become a wavy path about the line of motion of the body's centre of rotation. The black curved line, 'F', in figure 1, shows this path. Path of the peripheral point in space traces a wavy curve from  $P_1$  to  $P_2$ , while the centre of rotation of the body moves from  $O_1$  to  $O_2$  along the line XX, during one rotation of the body. At lower linear speeds, difference between segments of curved path (on either side of the linear path) is large. As the linear speed of the body increases (for the same rotary speed), lower segment becomes larger and the difference between upper and lower segments of the curve reduces.

Although, depending on body's linear speed in relation to its rotary speed, the peripheral point traces curves of loops, semi-circular curves or wavy path in space, it still moves in a circle with respect to the centre of rotation of the body. Motion of the peripheral point in a circular path is apparent only to an observer situated at the centre of rotation of the rotating body. Circular path of the peripheral point, noticed by the observer, is an illusion due to the observer not considering his own linear motion in space. In fact, every point in the rotating body, moving in linear path, appears to move around every other point in the same body. This is a false impression, created by choosing a moving point as a reference. Every point has its own independent path in space. Other than when the rotating body has no linear motion, path of the peripheral point does not trace a closed geometrical figure in space.

Rotating body is moving in a linear path. Center of rotation of the body has a linear motion along a straight line, XX as shown in the figure 1. For an observer, situated at one of its peripheral point, the centre of rotation of the body will appear to move around his location. He cannot observe his own true motion in space. He also cannot observe the linear motion of the rotating body (centre of rotation). Observed motion of the centre of rotation in a circular path around the peripheral point is an illusion.

Since the apparent motion of the peripheral point in circular path around the centre of rotation and the apparent motion of the centre of rotation in circular path around the peripheral point are only illusory motions, no true physical law can be based on them. Such illusory motions cannot be considered as proof of scientific laws. Observers, simultaneously situated at both these points will have apparent motions contrary to each other. None of them can observe the true motion of the points on the rotating body, in space. Real paths of any point on the linearly moving-rotating body can be viewed only from an external point. Origin of the frame of reference has to be outside the body.

A rotating body's integrity keeps the relative position of its peripheral points with respect to its centre of rotation. Its integrity provides certain attachment between these points. All through their motions, distance between the centre of rotation and a peripheral point remains constant. Each of these points can appear to move in circular paths around the other point. Therefore, in any system of bodies, where distance between two bodies is always kept constant (by some means irrespective of bodies' motions) and where each of the bodies appears to move in circular path around each other, the above given explanations are valid. Apparent circular paths of planetary bodies (noticed by the observer) about their central bodies are not real and hence, it is not right to consider them as facts to develop scientific laws on them.

## Forces on a planetary body:

In this article, all actions of a planet due to its inherent inertial motion are credited to linear motion/work (attained by the planetary body before it entered into its stable orbital path) and all actions due to the central force are credited to radial motion/work in it, towards the central body. A body is defined by the measurements of space, occupied by its matter content and by its mass, representing the quantity of its matter content. A free body tends to move in a straight line due to associated inertia. Apparent attraction due to gravitation between two bodies is the result of apparent attraction between their matter particles. Inertia of a body does not apply any effort on the body. While inertia maintains a moving planetary body in its straight line motion, it is the central force by its action on the body, which changes the direction of planet's motion and produce its spin motion. Actions on each body are between it and the surrounding 2D energy fields. Concurrent actions on two bodies, considered together, may be interpreted as an apparent action between them. Although gravitational action on each body is separate, such actions on the central and planetary bodies, when considered together, provide a central force (apparent attraction) between them. A planet is apparently attracted towards the central body. (Apparent) gravitational actions between two bodies take place only in common planes occupied by them. Actions, similar to the orbital motion of a planet analysed here, takes place on central body also.

A moving body contains the work required for its linear and spin motions. Work is stored in the form of distortions in the matter field of a macro body. In this article, we shall neglect all work, stored in a macro body, for the sustenance of its stability and integrity. We shall deal with only those additional distortions (work), introduced into body's matter field, by external efforts to change the state of body's motion. A free body, which is associated with such work, will continue its linear motion in a straight line at constant linear speed and maintain its spin motion at constant angular speed. Work contained in a planetary body was invested into its matter field by external efforts (forces), including apparent gravitational attraction towards the central body before its entry into orbital path. Another external effort is required to change the state of constant motions of the orbiting body. Forces in different planes do not interact. They act on the matter particles independently. Matter particles are moved by each of the forces in its own direction, to produce resultant direction of a combined-body's motion.

Magnitude of matter field-distortions (work) in a macro body, moving in circular path, does not change. However, to keep changing the direction of motion at a constant rate, distortions in its matter field are modified continuously. Changes in the matter field distortions produce body's accelerating stages. In the case of motion in a circular path, irrespective of changes in the matter field, magnitude of total matter field distortions in the matter field of the macro body is kept constant. Instantaneous velocity of the macro body depends on the magnitude of distortions in its matter field. Acceleration of the macro body depends on the variation in the work (magnitude or direction of distortions in the matter field) associated with it. A planetary body, simultaneously, maintains a constant acceleration towards the central body, maintains linear motion at constant velocity along the orbital path, maintains linear motion at constant velocity towards the central body and maintains (almost) constant acceleration of its spin motion.

In the following paragraphs, displacement of the planetary body along its orbital path is called planet's linear motion and planet's displacement towards the central body, by the (apparent) central force, is called radial motion. Disregarding the spin motion, a planet has two simultaneous (linear) motions, a linear motion nearly tangential to its orbital path and a radial motion towards the central body. Linear motion of the planet is deflected, outward from orbital path (away from the median path). Angle between the direction of linear motion and the tangent at the location of the planetary body on its orbital path, the 'drifting rate', produces a perpendicular component of the linear motion. This, a real motion of the planetary body (away from the centre of curvature of the path), replaces the assumed motion produced by the 'imaginary centrifugal force' on it. Major part of (linear) work

within a planet carries it along the orbital path. Relative direction of radial motion to the tangential linear motion varies at different points on the real orbital path. Most of the matter field distortions, producing linear motion and radial motion of the body, are in different planes. Hence, they do not produce resultant motions. However, simultaneous and independent displacements of the planetary body, produced by the matter field-distortions in different planes, may be understood together as its resultant motion.

In the following analysis, planetary orbit about a central body (moving in a much larger circular path) is considered. As a planet moves in its orbital path, its relative direction to central body changes through half a circle, alternately in either direction. This is in contrast with present assumption of a planet moving **around** the central body in full circles (an assumption created by change of reference frame). Changes in relative direction between the bodies cause variations in efforts and their actions. Explanations given below are for relative position of the central and planetary bodies, when the tangents to their paths are parallel and the bodies are moving in the same direction.

### Action of a central force:

Central force, between a planet and its central body, is provided by apparent gravitational attraction between them. [Real gravitational actions, by the 2D energy fields, pushing these bodies towards each other is considered as apparent attraction between them]. Direction of this apparent attraction, at datum points in the orbit (points on the orbital path where the planet is displaced by  $\pi/2$  radians from the median path), is perpendicular to planetary body's linear motion. Action of the central force depends on the magnitude of (radial) distortions; it is able to invest into the planetary body's matter field. Magnitude of (radial) matter field-distortions, a body is able to store is governed by its absolute linear speed (with respect to the space/2D energy fields). Action of apparent gravitational attraction is instantaneous and continuous. As long as the participating bodies occupy common planes, apparent gravitational attraction between the bodies, continues to invest additional distortions in their matter fields to produce inertial actions.

Figure 2 shows a spherical (homogeneous) planetary body of radius  $r$  and mass  $m$  with its centre at  $O_2$  and moving to the left (in relation to the central body, the planetary body is overtaking the central body). We shall consider the left half of the body. Magnitude of matter field density (density of additional distortions introduced into the matter field of a body) depends on the duration of action of an effort (force). Density of (radial) matter field distortions increases from  $C$  to  $O_2$ . Planet moves in the direction from  $O_2$  to  $C$ . Absolute linear speed of the body being  $V$  m/sec, whole body takes  $2r/V$  seconds to pass a point in space. Due to difference in sizes of central and planetary bodies, it takes more than an instant for the planet to move across the central body, in any tangential direction. Apparent gravitational attraction (central force) on the planet is in radial direction, parallel to  $AB$ , for whole of this time. Additional work introduced by the central force in a cross section of the planet depends on the time, during which it is under the influence of apparent gravitational attraction in a particular direction.

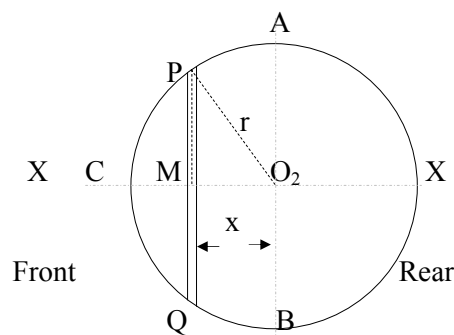


Figure 2

Take an elementary circular section  $PQ$  (cut by planes parallel to  $AB$  at distances  $x$  and  $x+dx$  from  $AB$ ) of thickness  $dx$ , perpendicular to the axis  $XX$ . Magnitude of matter field distortions in any part of the body is proportional to its volume.

$$\begin{aligned}
PM^2 &= O_2P^2 - O_2M^2 = r^2 - x^2, \quad CM = r - x \\
\text{Volume of PQ} &= \pi \times PM^2 \times dx = \pi(r^2 - x^2)dx \\
\text{Matter density of PQ} &= m \div \frac{4\pi \times r^3}{3} = \frac{3m}{4\pi \times r^3}
\end{aligned} \tag{1}$$

$$\text{Matter content of section PQ} = \frac{3m}{4\pi \times r^3} \times \pi(r^2 - x^2)dx = \frac{3m(r^2 - x^2)dx}{4r^3}$$

Using inverse square law for apparent attraction due to gravitation;

$$\text{Central force on section PQ} = \frac{3m(r^2 - x^2)dx}{4r^3} \times \frac{MG}{D^2} = \frac{3MGm(r^2 - x^2)dx}{4r^3D^2}$$

Where, M is the mass of the central body, G is the gravitational constant in 3D space system and D is the distance between the centres of section PQ and the central body. Central force is the rate of investment of (perpendicular) matter field distortions into section PQ of the planetary body with respect to the distance moved, towards the central body.

Central force acts on section PQ for the time, during which it exists under the effort. Since, we are considering the motion of the planet across its orbital path; we are interested only in those common planes, which are perpendicular to planet's orbital path and containing both the central and planetary bodies. As soon as the front edge of the planet reaches the perpendicular line passing through the rear edge of the central body, both bodies start to have common planes. Number of common planes increases as the planet moves forward to overtake the central body. Duration of action of the central force on the planet, in perpendicular direction to orbital path, is from the instant the planet's forward edge enters the common plane with the central body to the instant the planet's rear edge leaves the common plane with the central body. Duration of action of the central force on the planet, in perpendicular direction to orbital path before the section PQ comes in the common plane with the central body, is from the time planet's forward edge enters the common plane with the central body to the time, when the section PQ enter the common plane.

Distance between the front edge of the planet and section, PQ = (r - x).

Time duration = displacement / speed = (r - x) / V

Let the constancy of proportion between force and magnitude of distortions introduced by it is equal to k. This constant of proportion for different bodies is different. It depends on the size of the body in the direction of force, consistency of the body-matter and the body's matter density.

$$\begin{aligned}
\text{Magnitude of (radial) matter field distortions invested in PQ} &= \frac{3MGm(r^2 - x^2)dx}{4r^3D^2} \times \frac{(r - x)}{V} \times k \\
&= \frac{3MGmk}{4r^3D^2V} (r^2 - x^2)(r - x)dx
\end{aligned}$$

Magnitude of total (radial) matter field distortions in the hemisphere ACBO<sub>2</sub>A of the dynamic planet, when the whole planet is within the common planes with the central body,

$$\begin{aligned}
W_1 &= \sum_{x=0}^{x=r} \frac{3MGmk}{4r^3D^2V} (r^2 - x^2)(r - x)dx = \frac{3MGmk}{4r^3D^2V} \int_{x=0}^{x=r} (r^2 - x^2)(r - x)dx \\
&= \frac{3MGmk}{4r^3D^2V} \int_{x=0}^{x=r} (r^3 - r^2x - rx^2 + x^3)dx = \frac{3MGmk}{4r^3D^2V} \left[ r^3x - \frac{r^2x^2}{2} - \frac{rx^3}{3} + \frac{x^4}{4} \right]_0^r
\end{aligned}$$

$$= \frac{3MGmk}{4r^3D^2V} \left( r^4 - \frac{r^4}{2} - \frac{r^4}{3} + \frac{r^4}{4} \right) = \frac{3MGmk}{4r^3D^2V} \times \frac{5r^4}{12} = \frac{5MGmkr}{16D^2V}$$

Since the value of the gravitational constant  $G$ , in 3D space system, is determined experimentally, we can take that the operation by the constant of proportion,  $k$ , is also automatically accounted for in the value of  $G$ . Hence, we may neglect the factor  $k$  in the above equation.

$$\text{Thus,} \quad W_1 = \frac{5MGmr}{16D^2V} \quad (2)$$

Similarly, taking other (rear) hemisphere  $AO_2BEA$ , of the planetary body, as shown in figure 3, we may determine the work invested in it by the central force as follows;

Take an elementary circular section  $PQ$  (cut by planes parallel to  $AB$  at distances  $x$  and  $x+dx$  from  $AB$ ) of thickness  $dx$ , perpendicular to the axis  $XX$ . Magnitude of matter field distortions in any part of the body is proportional to its volume and its distance from  $C$ .

$$(PM)^2 = (O_2P)^2 - (O_2M)^2 = r^2 - x^2, \quad CM = r + x,$$

$$\text{Volume of section } PQ = \pi(r^2 - x^2)dx$$

Matter density of section  $PQ$

$$= m \div \frac{4\pi \times r^3}{3} = \frac{3m}{4\pi \times r^3} \text{ kg/m}^3$$

$$\text{Matter content of section } PQ = \frac{3m}{4\pi \times r^3} \times \pi(r^2 - x^2)dx = \frac{3m(r^2 - x^2)dx}{4r^3}$$

$$\text{Central force on section } PQ = \frac{3m(r^2 - x^2)dx}{4r^3} \times \frac{MG}{D^2} = \frac{3MGm(r^2 - x^2)dx}{4r^3D^2}$$

Central force is the rate of investment of matter field distortions in the section  $PQ$ , in the direction of central body.

$$\text{Time duration in which } PQ \text{ is under central force} = (r + x) \div V$$

(Taking the constant of proportion equal to  $k$ ), Magnitude of (radial) matter field distortions

$$\text{invested in } PQ = \frac{3MGmk(r^2 - x^2)dx}{4r^3D^2} \times \frac{(r + x)}{V}$$

$$= \frac{3MGmk}{4r^3D^2V} (r^2 - x^2)(r + x)dx$$

Total magnitude of (radial) matter field distortions in the hemisphere  $AO_2BEA$  of the dynamic planet,

$$W_2 = \sum_{x=0}^{x=r} \frac{3MGmk}{4r^3D^2V} (r^2 - x^2)(r + x)dx = \int_{x=0}^{x=r} \frac{3MGmk}{4r^3D^2V} (r^2 - x^2)(r + x)dx$$

$$= \frac{3MGmk}{4r^3D^2V} \int_{x=0}^{x=r} (r^3 + r^2x - rx^2 - x^3)dx = \frac{3MGmk}{4r^3D^2V} \left[ r^3x + \frac{r^2x^2}{2} - \frac{rx^3}{3} - \frac{x^4}{4} \right]_0^r$$

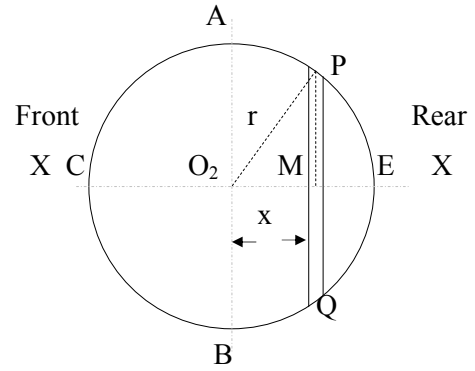


Figure 3

$$= \frac{3MGmk}{4r^3D^2V} \left( r^4 + \frac{r^4}{2} - \frac{r^4}{3} - \frac{r^4}{4} \right) = \frac{3MGmk}{4r^3D^2V} \times \frac{11r^4}{12} = \frac{11MGmrk}{16D^2V}$$

Since the value of the gravitational constant  $G$ , in 3D space system, is determined experimentally, we can take that the operation by the constant of proportion,  $k$ , is also automatically accounted for in the value of  $G$ . Hence, we may neglect the factor  $k$  in the above equation.

$$\text{Thus, } W_2 = \frac{11MGmr}{16D^2V} \quad (3)$$

Sum total (radial) work held in the body, from equations (3.8/4) and (3.8/5),

$$W = W_1 + W_2 = \frac{5MGmr}{16D^2V} + \frac{11MGmr}{16D^2V} = \frac{MGmr}{D^2V} \quad (4)$$

Unequal momenta of forces about the centre of gravity, of the free planet, cause its simultaneous radial and spin motions. Equal momenta on either side of centre of gravity, together, cause the radial motion of the planetary body towards the central body. They act as single set of work (force) through the centre of gravity of the planetary body. Remaining one-sided momentum produces a couple about centre of gravity and causes spin motion of the planetary body. Work, in the front hemisphere and equal part of work in the rear hemisphere, together, produce planet's radial motion towards the central body. Direction of radial motion, at the datum points, is perpendicular to the orbital path.

Total (radial) work acting through the centre of gravity,

$$W_g = \frac{5MGmr}{16D^2V} \times 2 = \frac{5MGmr}{8D^2V} \quad (5)$$

This work, of magnitude  $5MGmr \div 8D^2V$ , acts to produce planet's (radial) motion towards the central body. No body can stay motionless in space. Hence, the factor  $V$  is always of positive value.

Remaining (radial) work, acting about the centre of gravity of the body and producing spin motion of the planet,

$$W_s = \frac{MGmr}{D^2V} - \frac{5MGmr}{8D^2V} = \frac{3MGmr}{8D^2V} \quad (6)$$

{See the article "Planetary Spin"}

Magnitude of the central force and its components,  $W_g$  and  $W_s$ , also depend on the position of the planetary body in relation to the central body. In the relative position, considered above, direction of central force is perpendicular to planet's orbital path. There are points on the orbital path at which the planetary body experiences the central force in the same or opposite direction to the direction of its linear motion along the orbital path. At these points, magnitude of central force will be much higher and the magnitude of its spin component will be zero. At all other points in the orbital path, magnitudes of central force and its components will vary, cyclically, as the planetary moves along its orbital path.

### **Magnitude of radial velocity:**

Central body of a planetary system is very large, compared to a planet. Therefore, it takes some time for the planet to move across the central body, in any tangential direction. They maintain common planes, parallel to the radial direction, during this time. As long as the common planes are present, they are under apparent gravitational attraction in that radial direction. Apparent gravitational attraction, in any radial direction, begins as soon as the forward part of planet comes in line with the central body and continues to be present as the planet advances in its orbital path, moving across the

central body. Central force in radial direction ceases when the planet has fully crossed the central body in that tangential direction. At the end of this time, all the work invested into the planet's matter field, for the production of its radial velocity in this direction, has been utilized (to change the direction of linear motion and to spin the planetary body) and the planetary body will end its radial motion in this direction. Actions of the central force on the planetary body overlaps for near-by points on the orbital path. Radial displacement of the planetary body towards the central body, at every consecutive instant, is along different directions and it (in any radial direction) stops as soon as work introduced into the body for motion in that particular direction is lost from the body's matter field. Consequently, despite the continuous displacement towards the central body, a planet never reaches any nearer to the central body (disregarding variations required for eccentricity of the orbital path).

Equation (5) gives (radial) total matter field distortions (or work), held in the planet and producing its constant radial motion,  $u$ , towards the central body. Unlike in the normal cases, where an external force introduces matter field distortions in a body during its action, the case of planetary system is different. This is because of the constant change in the direction of motion of the planetary body. In any radial direction, magnitude of matter field distortion remains constant. That is, there is no natural accelerating stage for the body. The body moves at a constant radial velocity along any radius in consideration (this consideration lasts only for an instant). Accelerating stage to develop this constant velocity took place before the body came in the line of direction considered. Kinetic energy of a body, moving at constant speed,  $u = \frac{mu^2}{2}$ . Mass of the planetary body 'm' is constant and its kinetic energy depends on its velocity.

$$\text{Comparing these two; } \frac{mu^2}{2} = \frac{5MGmr}{8D^2V}$$

$$\text{Radial velocity of the planetary body towards the central body, } u = \sqrt{\frac{5MGr}{4D^2V}} \text{ m/sec} \quad (7)$$

Although this (radial) velocity appears to be of constant magnitude (disregarding changes in  $D$  and  $V$ ), it is being renewed at every instant. Work is used up and new work of equal magnitude is invested throughout the planetary body's matter field. Continuous loss of work from the matter field keeps the velocity of the body constant despite continuous investment of work from the matter field. Investment of work into the matter field produces a body's acceleration. Yet, in this case, final velocity is constant irrespective of body's acceleration. This is because of the limitation on body's (matter field's) ability to store more work (in radial direction) than a constant maximum magnitude, due to planetary body's linear motion. Planetary body starts to accelerate at a rate 'a' in its planes towards the central body, when it starts to cross a common plane with the central body. Acceleration in this direction ceases when the whole body has crossed the common planes with the central body in that radial direction. Thereafter it is unable to store more work of this nature. Long before this time, it would have started similar actions in nearby planes also.

Constancy of radial velocity is mentioned only to emphasize the continuous action of central force in any particular direction does not change its radial velocity in that direction. However, depending on the present position of the planetary body in its orbital path, radial velocity of the planetary body varies continuously and cyclically.

## Orbital motion:

A planetary system is formed by a group of large bodies in space. Bodies of this group move together along a median path, while individual bodies have independent relative motions within the group. The planetary system that includes the sun is called the solar system. Path of each body in the system is affected by the presence of all other bodies. We may, for the time being, neglect effects on their paths by the presence of other bodies in space, as they are very small. There may also be smaller

bodies called satellites in a planetary system. Satellites being very near to the planets, they form (sub) planetary system with their mother planet, within the larger planetary system. Largest body in the group has its path nearest to the median path and its path is least perturbed. This body acts as the leader of the group and it is called the central body of the planetary system. All other bodies in the planetary system move along with the central body, while their paths are perturbed by the presence of all other bodies in the system. For the explanations below, we shall consider a planetary system containing a central body and one planetary body.

With reference to the planetary body, the central body appears to orbit around the planetary body and with reference to the central body, the planetary body appears to orbit around the central body. Disregarding the eccentricity of an orbit, distance between the central body and the planetary body remains constant. By these characteristics, a planetary system functions as a rotating body moving in linear path. Planet takes the place of a peripheral point and the central body takes the place of centre of rotation, in the above given explanation on the ‘linear motion of a rotating body’. Median path of the planetary system is a very large circle. A small part of this very large circle is considered as a straight line for the explanations.

Actions of the central force on a planet and its orbital motion are independent of all other bodies, including the central body. Role of the central body or any other body in the vicinity is to limit the extent of 2D energy fields acting on one side of the planet. Rest of all actions on the planet are performed by the 2D energy fields. Although a planetary body appears to move in orbital path around a central body, in reality, it has an independent path of motion of its own. Apparent gravitational attraction towards the central body causes its path to deviate from straight line to move about and along with the central body in its motions. Due to the gravitational actions, orbiting bodies appear to influence the direction of each other’s motion and create perturbations in their paths. Since a planet is very small compared to the central body, deviations in its path are more prominent. When these deviations are observed about a central body that is assumed to be static, path of the planet appears to be an orbit around the central body. This is the apparent orbit of the planet, which we observe in everyday life.

Similarly, relative to an assumed static planetary body, apparent direction of motion of the central body is around the planet. Few centuries back, when an earth-centred universe was in prominence, this apparent motion was considered as the true. Later as the science progressed, a sun-centred universe came into prominence. Earth, orbiting around the sun, is considered true in a sun-centred universe. Although we now know that the sun is no more at the centre of universe, our view of planetary orbits in a sun-centred universe has not changed.

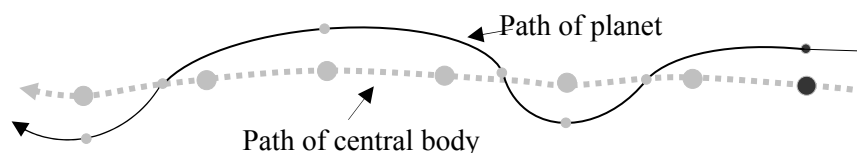


Figure 4

Orbital motion is apparent only with respect to the participating bodies. With respect to absolute reference, a planet does not orbit around the central body. Path of a planet’s motion is wave-like, along the central body’s path, the planet periodically moving to the front and to the rear of the central body. In figure 4, path of the 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 planet. Arrow in black wavy-line shows planet’s orbital path. Path of a satellite of the planet will be a wavy-line about planet’s path. Central body and the 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 the centre

of the central body's curved path and the wave pattern in its path is caused by the presence of the central body. Such changes in the path of a free body may be attributed to perturbations caused by presence of nearby bodies. These perturbations look like orbital motion around a central body, only when they are referred to an assumed static central body in a relatively small system of bodies. This argument can be carried further to show that with respect to absolute reference there is no natural orbital motion (around central bodies) at all, except orbital motions of bodies around the (static) galactic centres.

Both, the planet and the central body move in the same direction about the same median path in space. Since the circular orbital motion is an apparent phenomenon, either of the bodies can be considered as the central and the other as its planet. Planetary laws are equally valid in either case. Although it is generally stated that the earth orbits around the sun in eastward direction, it is equally valid to state that "the sun orbits around the earth in westward direction". However, when more than two bodies are considered as a single system, it is more convenient to take the common and most prominent body as the central body and to take other bodies as planetary or satellite bodies.

Larger orbital path of a planet is around the galactic centre. It is very large and contains many points of similar appearance in relation to the central body of a planetary system. Hence, a much smaller structure 'the apparent orbit' with unique reference points on it is used. Apparent orbit is a small part of the larger orbit between two identical appearances of the central body from the planet (e.g.: one solar year). It is an imaginary concept. As such, it has no logical basis. It depicts the appearance of a system, where it is assumed that the central body, by some imaginary mechanism (change of reference frame), is held stationary at the centre of the orbit. Only cause of actions within the system is the central force, due to mutual apparent gravitational attraction, which accelerates a planet towards the centre of the apparent orbit – the central body. Parameters of this action are mathematically manipulated to produce the required orbital motion around a central body that matches the observations. [In case of earth, such mathematical treatments are also used to establish proofs of validity for "Laws of motion" and "Laws of universal gravitation"]. While doing this, much greater motions of the planetary body before it became a planet and the motion or path of the central body are ignored. An apparent orbit is convenient to predict cyclic features that take place annually. However, taking an apparent orbit as the real motion of a planet is highly illogical and incorrect.

A non-circular apparent orbit has two reference points on it, periapse and apoapse. They are situated diametrically opposite. Apoapse is the point on the orbital path, where the planet is considered to be slowest and farthest from the central body and periapse is the point on the orbital path, where the planet is considered to be fastest and nearest to the central body. In real orbital motion of the planet, periapse is a point on its path, where it is nearest to the central body but the planet need not be fastest at this point. And apoapse is the point on its path, where it is farthest from the central body, but the planet need not be slowest at this point. In case of earth, these points are called perihelion and aphelion, respectively.

In an apparent orbit, direction of radial motion of the planet towards the central body is always (almost) perpendicular to its orbital path. In real orbital motion, it is not so. Radial motion of a planet is perpendicular to the orbital path only at datum points situated farthest and nearest to the galactic centre. At all other points on the orbital path, angle between radial motion and orbital path varies as the sine of relative angular position of the planet with respect to the central body and the median path.

Figure 5 compares the real path of an orbiting body and its apparent orbit for the duration of one apparent orbital period. Black central line is Central body's path. Grey, wavy line is the path of the planet. Larger black circle shows the central body and the circles in dotted line show its future positions. Small black circle shows the orbiting body and the grey circles show its future positions. Double headed arrows show the apparent central force between the bodies at various positions as they move along their paths. As a planet moves, its apparent orbit moves along with the central body.

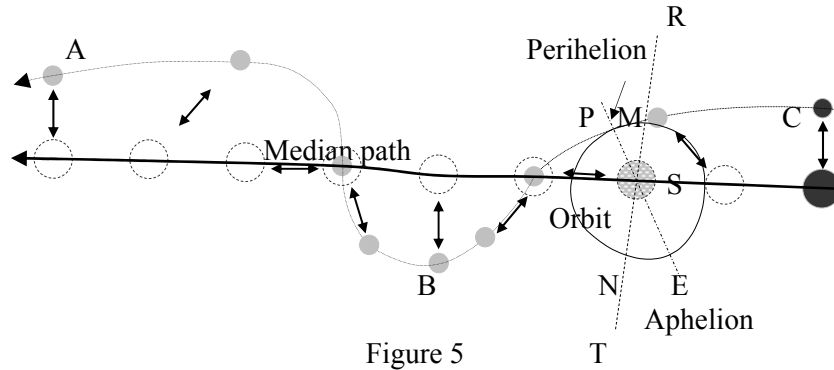


Figure 5

Apparent orbit of the planetary body, when it is at position P with the central body at S, is shown by the oval in figure 5. Planet's perihelion is at P and aphelion is at E. In real motion, highest and lowest linear speeds of the orbiting body occur, when it is at  $90^\circ$  away from the path of the central body, at M and B, respectively. All parameters of an apparent orbit and the orbiting motion are related to perihelion and aphelion. From its position at C, until B, the orbiting body is in front of the central body and hence it is retarded in its linear motion. From B to A, the orbiting body is behind the central body and hence it is accelerated in its linear motion. Line RST is the radial line connecting the central body to the centre of its curved path (galactic centre). Acceleration and deceleration of the planet change over at points M and B. These points are fixed relative to the path of the central body. Point M, on the outer side of central body's path may be called 'outer datum point' and point B (corresponding to point N on the apparent orbit), on the inner side of central body's path may be called 'inner datum point'. Datum points have only a vague relation to apparent orbit. A circular apparent orbit around a central body represents an ideal orbit about the central body, which may be called 'datum orbit'.

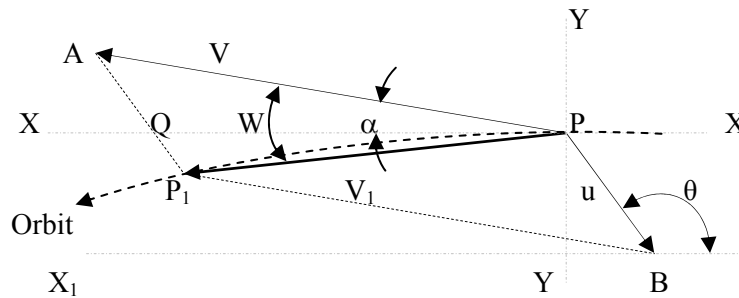


Figure 6

In figure 6, P is the planet at a point on its orbital path. XX is the tangent to the orbital path at P. PA is the absolute linear velocity of the planetary body, V, in magnitude and direction. Due to inertia, the planet tends to maintain the direction of its linear motion. Angle between V and the path of the body varies as the body moves in its curved path. Total angular displacement produces body's orbital motion. At any instant, V is deflected from XX by 'drifting rate',  $-\alpha$  (clockwise deflection). Radial motion (velocity) due to the central force is  $PB = u$ . Direction of u is towards the central body. Angle between u and the tangent XX, at P is  $+\theta$ , equal to the angular displacement of the planet in its orbit from a reference point,  $X_1$  on the median path.  $PP_1$  is the resultant motion of the body,  $V_R$ , and it makes an angle W with V. Due to the action of the central force (radial motion u), linear motion of the body is deflected from PA to  $PP_1$ .

$$\text{Angle between } V \text{ and } V_R = \angle APP_1 = W, \quad \angle QPB = \angle PBX_1 = \theta$$

$$\text{Angle between } V \text{ and } u = \angle APB = \theta + (-\alpha)$$

$$\tan W = \frac{u \sin[\theta + (-\alpha)]}{V + u \cos[\theta + (-\alpha)]} \quad (8)$$

$W$  is the rate of angular deflection between present velocity,  $V$ , and resultant velocity,  $V_R$ . It may be called the ‘deflection rate’.  $\alpha$ , the ‘drifting rate’ is the rate of angular deflection between the present linear velocity,  $V$ , and the tangent. In order to make the path curve towards the median path, resultant of  $W$  and  $\alpha$  should be in the same direction as that of  $u$ . Vertical component (to the tangent  $XX$ ) of present velocity  $V$  is a real motion, substituting for the effect of the (presently) imaginary ‘centrifugal force’. This part of real motion produces the drifting rate,  $\alpha$ .

Figure 7A shows the real orbital paths of inner members of solar system. Planets and the sun, shown in the figure, are not to scale. Eccentricities of orbits are ignored. Relative positions of sun and the planets, shown on the right, are as on 3<sup>rd</sup> May 2002 [Reference: ESA Website]. Galactic centre is on the lower side and the solar system is depicted as rotating anti-clockwise around the galactic centre. Arrows at the ends of orbital paths show the direction of motion of the sun and the planets. Path of the sun is shown as a straight line and its perturbations, caused by the planets, are not shown in the figure. Curved segments of planetary orbital paths, below the sun’s path (on the side towards the galactic centre), appear narrower because of very small scale of distance used in the figure. It can be seen from the figure that the sun and planets move together along a common median path around

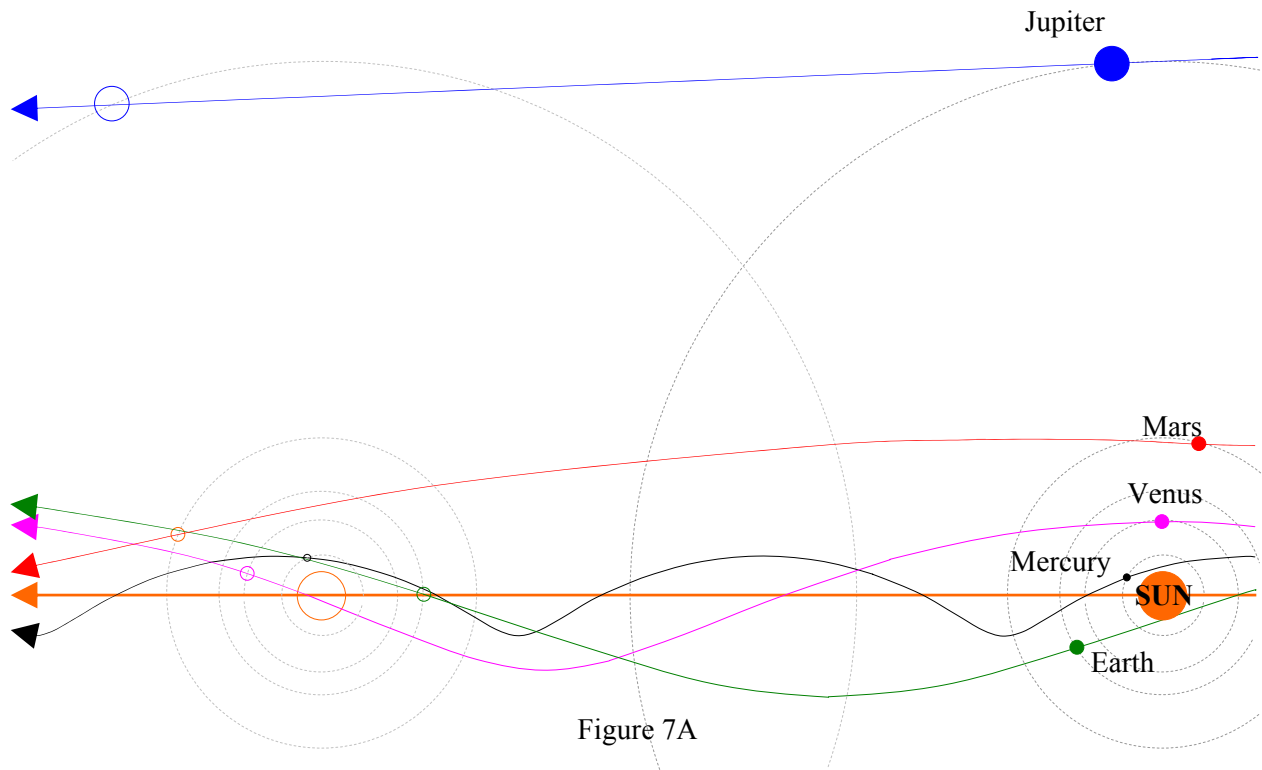


Figure 7A

the galactic centre. Presence of number of bodies in the system causes perturbation to the paths of all members. These perturbations, when observed with respect to any member of the system (which is presumed to be static) gives rise to the apparent orbits of closed geometrical (circular or elliptical) figures around the member, which is assumed to be static. Apparent orbits are shown by the grey lines around the sun. Dim set of figures on the left shows the relative positions of the members of the system and their apparent orbits, five months later. Similar apparent orbits and the planetary system can be built about any member of the system. They all are imaginary. Until last days of 16<sup>th</sup> century A.D., solar system was considered with earth based apparent orbits. Later on; due to popularity of Kepler’s planetary laws and Newton’s support to the same, the present system of sun-based apparent

orbits for the solar system came into prominence. However, the imaginary nature of these orbital systems continues to be disregarded even after realising the movement of the central body in space.

All bodies in the asteroid belts are planetary bodies with respect to the sun. Their real orbital paths, in the asteroid belt, are similar to planetary orbits about the sun.

Figure 7B shows the real orbital path of moon (a satellite) about the earth. Orange circle shows the sun and the orange arrow shows sun's path as a straight line. Green circle shows the earth and the curved green arrow shows earth's real orbital path for five lunar months. Blue wavy arrow shows the real orbital path of the moon. Black dashed circle around the sun shows the apparent orbit of earth. Black circle in dashed line around the earth shows the apparent orbit of moon around the earth. Lower parts of the real orbital path of the moon about the earth are narrower because of very small scale of distance chosen for the figure. The figure is not according to any particular scale. Relative positions of sun, earth and moon are shown as for full moon day. Dim figures to the left show their relative positions and apparent orbits for subsequent full moon days. Eccentricities of the apparent orbits are not considered. Real orbital paths of all satellites about their corresponding planets are similar.

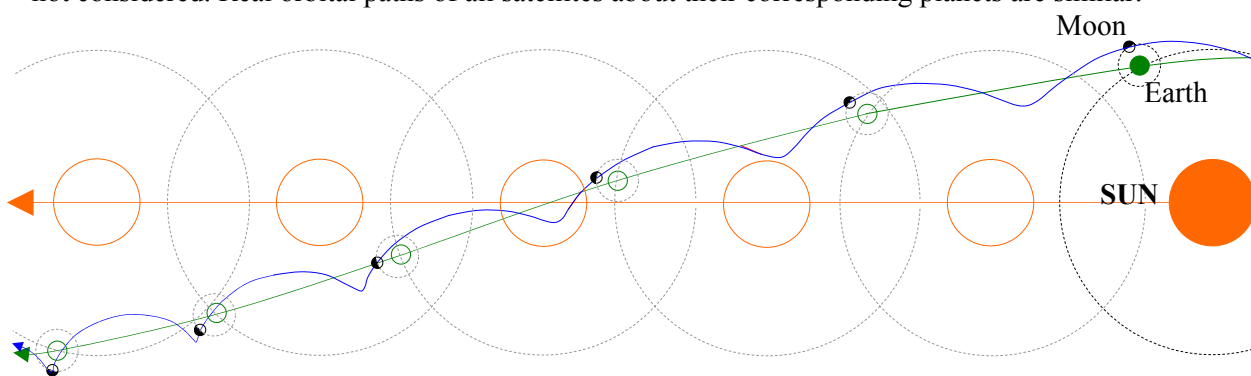


Figure 7B

Some planets are found to have many smaller bodies orbiting about them. These, when depicted in their apparent orbits, they make picturesque rings about the planets. However, their real orbits are similar to the orbital paths of satellites about the planets. These bodies form a swarm around the planetary body and move along with the planetary body in its motions. Figure 7C shows the real orbital paths of these bodies about the planet. Figures on the right show the relative positions of the bodies and their apparent orbits. Orange circle shows the sun, black circle shows the planet and the coloured circles show three smaller bodies in the ring, situate in the same radial line from the planet. Orange arrow shows the path of the sun in a straight line. Black curved arrow shows the real orbital path of the planet. Coloured curved arrows show the real orbital paths of the smaller particles in the rings. Dim figures on the left show the relative positions of the bodies and their apparent orbits after lapse of certain time.

Planetary bodies have lower rates of angular displacement with respect to their central bodies as their distance from the central body increases. Their orbital paths cross each other at different places in space. Due to their different angular speeds, there is a possibility for any two planets in a planetary system (or for any two satellites of a planet) to come very near to each other. At certain point of time in future, it is possible for any two planets in a planetary system (or for any two satellites of a planet) to collide into each other and destroy. In case of smaller bodies, forming rings about a planet, they have identical angular speed with respect to their parent body. This prevents them from colliding into each other during their motion along with their central body.

This swarm of smaller bodies about a planet also obey all rules of planetary motions. Only those smaller bodies in the swarm, which are in (or very nearly in) the orbital plane of the planetary system can survive in the rings, as explained later in this article. All bodies, which do not conform to the

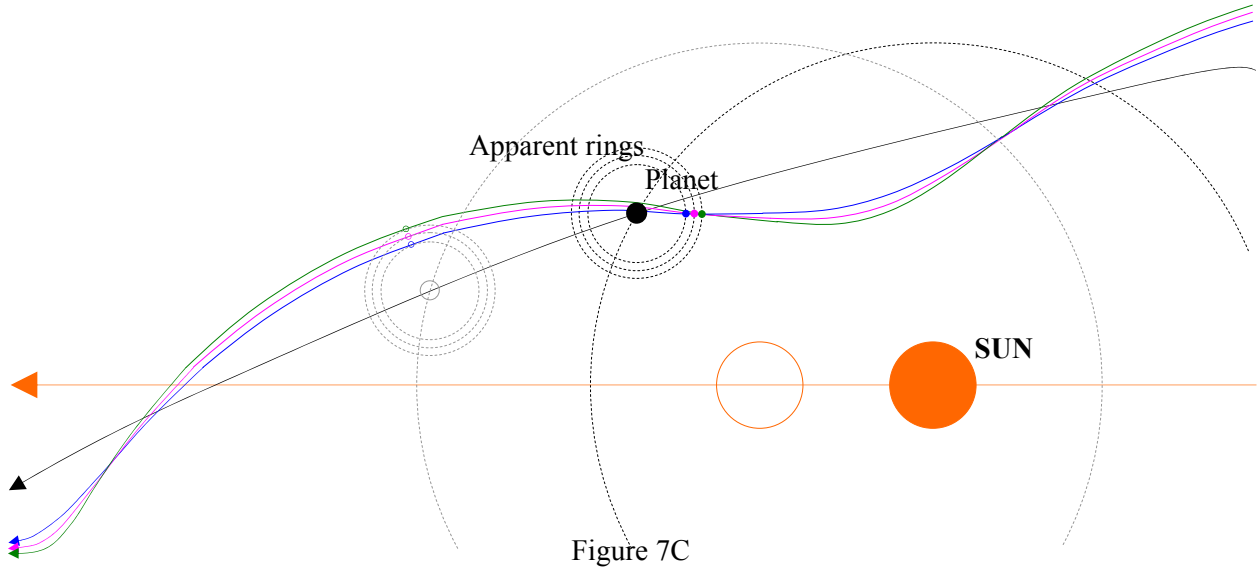


Figure 7C

planetary laws, will be automatically removed from the system by mutual collisions or rejections. Hence, the apparent rings about a planetary body are very thin and around planet's equator. Although, they are depicted as rotating around the planet, they also move along with the planet in its linear motion as shown by the coloured curved lines in the figure 7C. Since their angular speed is the same, linear speeds of these bodies increase as the distance from the planet increases (within the escape velocity corresponding to the planet). Due to centrifugal action, caused by their angular speeds, larger (by matter content) bodies tend to distribute farther from the planetary body and smaller (by matter content) bodies remain near to the planet's surface..

### Circular orbit:

For motion in a circular path,  $V_R = V$ . That is, at any instant, the resultant linear speed of the body in its curved path is equal to its present speed. In a circular orbit,  $W$  is constant. There is no angular acceleration. Hence, the drifting rate remains constant and equal to  $-\alpha$  all around the path. If a negative drifting rate ( $-\alpha$ ) can be maintained constant by external means or by natural process, the resultant linear motion of the body along its curved path deflects at a constant rate and its magnitude remains a constant equal to its present (instantaneous) linear speed.

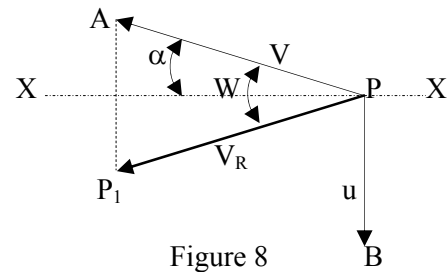


Figure 8

In figure 8;  $V$  is the present (absolute linear) speed, deflected from the tangent  $XX$  at  $P$  by an angle  $(-\alpha)$ ,  $u$  is the radial motion perpendicular to the tangent.  $PP_1 = V_R$ , is the resultant motion of the body, deflected from  $V$  by an angle  $W$ .

$$\angle APB = \frac{\pi}{2} + (-\alpha)$$

$$V_R^2 = V^2 + u^2 + 2Vu \cos\left[\frac{\pi}{2} + (-\alpha)\right], \quad V_R^2 = V^2 + u^2 - 2Vu \sin(-\alpha)$$

For motion in a circular path;  $V_R = V$ , Putting  $V$  in place of  $V_R$ ,

$$V^2 = V^2 + u^2 - 2Vu \sin(-\alpha), \quad u^2 = 2Vu \sin(-\alpha), \quad u = 2V \sin(-\alpha) \quad (9)$$

$$\sin(-\alpha) = \frac{u}{2V} \quad \text{or} \quad (-\alpha) = \sin^{-1} \frac{u}{2V} \quad \text{radians} \quad (10)$$

Putting the value of 'u' from equation (11) in equation (10),

$$\tan W = \frac{2V \sin(-\alpha) \cos(-\alpha)}{V - 2V \sin(-\alpha) \sin(-\alpha)} = \frac{-2V \sin \alpha \times \cos \alpha}{V - 2V \sin^2 \alpha} = \frac{-\sin 2\alpha}{1 - 2\sin^2 \alpha} = \frac{-\sin 2\alpha}{\cos 2\alpha}$$

$$\text{Deflection rate, } W = \tan^{-1} \frac{-\sin 2\alpha}{\cos 2\alpha} = \tan^{-1}(-\tan 2\alpha) = -2\alpha \quad (11)$$

$$\text{Putting value of } \alpha \text{ from equation (10), } W = -2\alpha = 2\sin^{-1} \frac{u}{2V}, \quad \sin \frac{W}{2} = u \div 2V \quad (12)$$

For a circular orbit, where direction of W is positive:

$$\text{Drifting rate, } \alpha = W \div 2 \quad \text{in negative direction.} \quad (13)$$

This is the condition, required for a circular orbital path around a central body or circular parts of other orbital paths. Resultant linear speed of a planet along the curved path remains a constant, equal to its present (instantaneous) linear speed. Angular speed of the planet (deflection rate) is equal to twice the drifting rate (in opposite angular direction) and it is a constant. Drifting rate of a planet, required to achieve a circular orbit (in this case) is less than the angle of contingence at the point of initial entry on the datum orbit (clockwise from the tangent at P) and it is precisely equal to half the rate of deflection rate produced by the central force at that distance. Hence, the body is required to initially approach the entry point P from within the datum orbit. These conditions can be met only in cases, where the orbit is formed around a static central body. All bodies in nature, excepting stable galaxies, are under continuous motion. Hence, formation of a circular orbit around a (moving) central body is impossible.

All natural planetary bodies are much smaller than their central bodies and they approach their orbits from outside their datum orbits. In real orbital motion, a planet traces segments of curved paths on either sides of its median path. A circular orbital path requires semi-circular paths on either sides of median path. Due to constantly changing relative direction of central force, it is also impossible to maintain constant angular speed by a planet about a moving central body. Consequently, natural planetary bodies cannot have circular orbits.

Exceptions to the above are probable cases of binary systems with linear motion perpendicular to their plane or other planetary systems formed by explosion of a static parent body, where the planets are thrown away from a static central body to enter their orbits from within. Circular orbit is a critical condition. Parameters of a body (maintained in a circular orbit by external means) are very precise. Once in the orbit, the drifting rate can be easily changed by external factors. Changes in the masses of the planetary and central bodies or their speeds due to external influence are bound to affect the stability of a circular orbit due to changes in the drifting rate. Collision with debris in space or even uneven distribution of mass of the bodies can influence the state of a circular orbit. It should also be noted that no bodies, smaller than a galaxy, can remain static in space.

To form a circular apparent orbit, parameters of a planet should satisfy the equation  $W = 2\sin^{-1}(u \div 2V)$  at every point on its orbital path. All factors in the equation remain constants. Apparent circular orbit is the smallest apparent orbit of a planetary body. It is the 'datum orbit' of the body for its present parameters. This equation is also applicable to circular parts of non-circular orbits. Every stable orbital path has two points on it, for every completed cycle, which corresponds to circular orbital paths.

## Elliptical Orbit:

Variations in the parameters of an orbiting body change its datum orbit. Consequently, even if a body was in an apparent circular orbit, its datum orbit will change on variation of any parameter.

Such a change or a difference in the drifting rate changes the shape of the orbital path. Non-circular apparent orbits are based on the datum orbit of the body. A deformed datum orbit becomes non-circular apparent orbit of the body. Deformation of the datum orbit is with respect to two points (mid-points), which are on diametrically opposite sides on the apparent orbit. Either forward or rearward part of non-circular apparent orbit is placed within and the other part is placed outside the datum orbit.

Since a planet moves in a non-circular path, tangent to a point on the orbit is not perpendicular to the radius of the orbital path (along which the central force is acting). But, there are two points that lie on the orbital path (for every completed cycle), at which the conditions required for circular orbits are satisfied. At these points, direction of radial motion is perpendicular to the tangent and direction of change in the length of apparent orbit's radius reverses. If the radius was increasing before, after crossing this point, it will gradually decrease till the body reaches a similar point on the diametrically opposite side of the apparent orbit. At this point, direction of change in the distance between the bodies reverses and the radius gradually increases till the body reaches the original point on the apparent orbit. Periodic changes in the length of radius of the apparent orbit about a mean value sustain the stable orbital path. Points, where these reversals occur are the perihelion and aphelion at which the bodies are nearest or farthest from each other. Other reference points are outer and inner datum points, where the planetary body attains highest and lowest linear speeds, respectively.

In case of real motion, an orbital path is not around the central body but it oscillates about a common median path, shared by the central body. Angular speed of an orbiting body does not correspond to circular or elliptical paths. Deflection rate of orbital path from the median path is limited, alternating on both sides; where as, a total deflection of  $2\pi$  radians in the same direction is required for every apparent orbit. Linear motion of the planet is accelerated up to the outer datum point, when the planet moves to the front of the central body or it is decelerated up to the inner datum point, where the planetary body falls behind the central body. Highest and lowest speeds of the planet occur at these datum points. They need not coincide with either perihelion or aphelion of the apparent orbit, assumed above. Datum points of orbital path are situated on radial lines of the galactic radius (line perpendicular to the median path) and passing through both the central and planetary bodies. Points of perihelion or aphelion indicate the points, on the path of the planet, which are nearest and farthest from the central body. They have no other relations to the motions of the orbiting body. Perihelion and aphelion of an orbit may be displaced along the orbital path without affecting other parameters (excepting the planetary spin speed) of orbital motion. But the points, at which the acceleration / deceleration change-over takes place, are fixed with respect to the median path of the central body and depend on the relative position of the planetary body to the central body.

Part A, in figure 9, shows the planetary motion at the perihelion of an orbit and part B, in figure 9, shows the planetary motion in the same orbit at its aphelion.  $V$  is the present speed, ' $u$ ' is the radial speed and  $V_R$  is the resultant speed of the body. Drifting rates are equal to  $-\alpha$ .  $W$  is the deflection rate of the resultant motion. Changes due to the angular acceleration/deceleration add to the drifting and deflection rates. Motions of the planetary body at perihelion and aphelion (of its non-circular orbital path) exhibit properties of circular orbit. Angles between ' $u$ ' and tangents at perihelion and aphelion are  $90^\circ$  each.

Putting drifting rate,  $-\alpha = W/2$  and  $\theta = \pi/2$  in equation (10);

$$\tan W = \frac{u \cos \frac{W}{2}}{V - u \sin \frac{W}{2}} \quad (14)$$

$$V \sin W - u \sin W \sin \frac{W}{2} - u \cos W \cos \frac{W}{2} = 0,$$

$$V \sin W - u \cos \left( W - \frac{W}{2} \right) = 0, \quad 2V \sin \frac{W}{2} \cos \frac{W}{2} - u \cos \frac{W}{2} = 0,$$

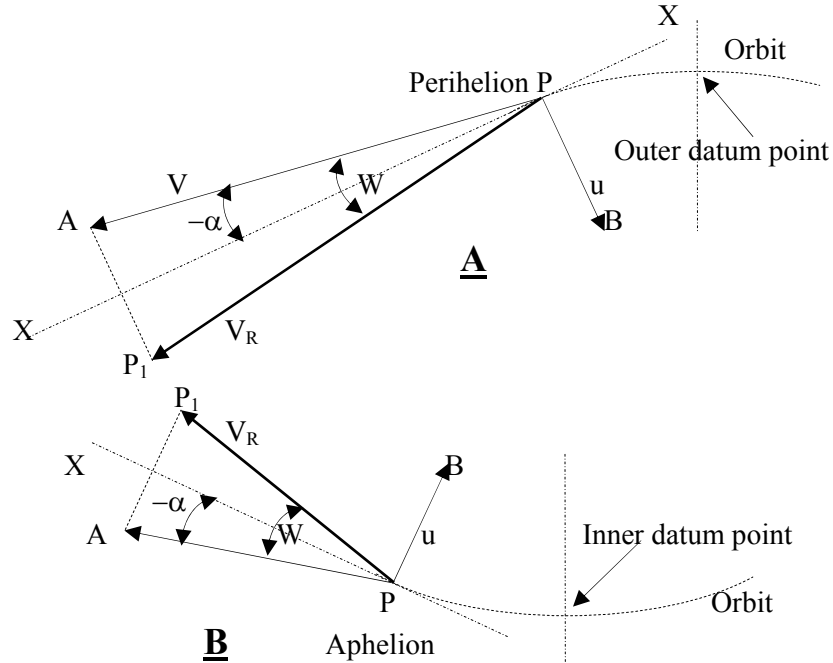


Figure 9

$$2V \sin \frac{W}{2} - u = 0, \quad \sin \frac{W}{2} = u \div 2V, \quad W = 2 \sin^{-1} \frac{u}{2V} \quad (15)$$

This is same as equation (12) obtained for a circular orbit. Since the curvature of the path varies continuously, this circular behaviour lasts only for an instant. As soon as the points of perihelion or aphelion are passed, planetary body will revert to pursue its non-circular path. Drifting rate at perihelion,  $\alpha_{\text{peri}}$ , is half of deflection rate,  $W_{\text{peri}}$ , and at aphelion; drifting rate,  $\alpha_{\text{aphe}}$ , is half of deflection rate,  $W_{\text{aphe}}$ , in magnitudes. As shown in figure 8 A & B, directions of drifting rates with respect to radial motion are always the same. Included angle between  $u$  and direction of approach are of the same sense. In a non-circular orbit; equation (8) gives the deflection rate. Equation (12) for circular orbit is applicable to a non-circular orbit at its perihelion and aphelion, where circular orbital-conditions exist.

Putting value of  $u$  from equation (7) in equation (15);

$$\text{At perihelion or aphelion, deflection rate, } W = 2 \sin^{-1} \frac{\sqrt{\frac{5MGr}{4D^2V}}}{2V} = 2 \sin^{-1} \frac{\sqrt{5MGr}}{\sqrt{16D^2V^3}} \quad (16)$$

Deflection rate, 'W' for perihelion and 'W' for aphelion are in opposite directions. If the planetary body has entered its datum orbit from within (with negative drifting rate), it will move towards its aphelion, where conditions of circular orbit takes place. Similar conditions (as required for circular orbit) should also repeat at a point  $180^\circ$  (in apparent orbit) away from the perihelion/aphelion, as the case may be. A stable orbit can be formed only if these conditions are met. At perihelion, direction of change in the distance between the planetary and central bodies reverses. The planetary body moves towards its aphelion, where condition for circular orbit is fulfilled once again. At mid-points between perihelion and aphelion,  $W$  becomes equal to  $-\alpha$ . Resultant angular speed of the body becomes zero. For an instant, planetary body moves in a straight line. Direction of linear motion of the planetary body is tangential to the orbital path at these points but direction of

radial motion is not perpendicular to the tangent. Therefore, conditions for circular orbit are not fulfilled. Tangents at these points are not parallel to the major axis of the apparent orbit. In an elliptical path, tangents at the ends its minor axis are parallel to major axis. In this case, they are not so. Hence, apparent orbital path of a planet is oval (with its narrower end towards the aphelion) rather than an ellipse. However, due to very small eccentricity of the apparent orbits, we come across in nature; they are usually considered as elliptical or circular. Present planetary laws are formed for (the imaginary) elliptical apparent orbits.

After the mid-point, angular difference between the radial and linear motions diminishes. When the planetary body has moved from this point by an angular displacement equal to the deflection of perihelion/aphelion from the datum points, linear and radial motions of the planetary body become co-linear. At this point, there are no deflection rates of the body due to central force. However, the body continues to move in its curved orbital path under the influence of drifting rate, which continues to decrease in magnitude. Once this point is passed, direction of angular difference between linear and radial motion reverses. Deflection rate,  $W$ , and drifting rate,  $\alpha$ , both are in the same direction for a short while until  $\alpha$  changes its sense. The planetary body will angularly accelerate till it reaches another point, where conditions for circular-orbital motion are fulfilled, where  $W$  and  $\alpha$  are in opposite directions and magnitude of  $W$  is twice that of  $\alpha$ . This is the aphelion of the orbit. Thereafter, similar processes continue to sustain stable orbital motion of the planetary body.

$$\text{Resultant orbital angular speed at perihelion} = W_{\text{peri}} - \alpha_{\text{peri}} = \omega_{\text{peri}}$$

$$\text{Resultant orbital angular speed at mid-point} = W_{\text{mid}} - \alpha_{\text{mid}} = 0$$

$$\text{Resultant orbital angular speed at aphelion} = W_{\text{aphe}} - \alpha_{\text{aphe}} = \omega_{\text{aphe}}$$

$$\text{Time to move from perihelion to aphelion} = T \div 2, \quad \text{Where, } T \text{ is orbital time period.}$$

Resultant orbital angular speed decreases from  $\omega_{\text{peri}}$  at the perihelion to zero at mid-point, increases from zero at mid-point to  $\omega_{\text{aphe}}$  at aphelion, decreases from  $\omega_{\text{aphe}}$  at the aphelion to zero at mid-point and increases from zero at mid-point to  $\omega_{\text{peri}}$  at perihelion.

Taking variation in the angular speed to be uniform;

$$\text{Total difference between angular speeds at perihelion and at aphelion} = \omega_{\text{peri}} + \omega_{\text{aphe}}$$

$$\text{Orbital angular acceleration / deceleration} = (\omega_{\text{peri}} + \omega_{\text{aphe}}) \div \frac{T}{2} \quad (17)$$

Location of ‘perihelion’ or ‘aphelion’ on an orbital path depends on the location of point of entry of the planetary body on the datum orbit and its drifting rate at the time of entry. For the appropriate drifting rate, the point of entry can be the perihelion or aphelion of the orbit. Location of perihelion/aphelion can shift along the orbital path later due to external influences, whereas, datum points of the orbital path remain at their relative positions with respect to central body.

### Limits of angular speeds at the point of entry:

Orbital path of a planetary body is a path in space, whose parameters are related to the central body. It is improbable for planets to be born in their orbits. They have to come to their orbits from space, away from orbital path. For a smooth transition from their motion outside the orbit into the orbital path, all their parameters of motion at the point of entry should be same, as if they were moving in the orbit at that point. Central force is active on planetary bodies even when they are very far from orbital path. Hence, parameters of planetary bodies’ motions are modified continuously, even before they enter their orbits. A planetary body enters its orbit in near-tangential direction subject to the following limits. Bodies, approaching the point of entry into datum orbit, outside

certain limits of their angular speeds, are unable to form stable orbits. As the magnitude of drifting rate,  $\alpha$ , approaches a limit in negative (clockwise) direction, deflection rate,  $W$ , becomes insufficient to overcome the drifting rate and the direction of the resultant motion,  $V_R$ , becomes parallel to the tangent. Such a body is not able to form an orbit.

$$\text{When } V_R \text{ is along the tangent, } \frac{u}{V} = -\text{Sin}\alpha, \quad -\alpha = \text{Sin}^{-1} \frac{u}{V}$$

This is the lower limit of drifting rate at the point of entry (from within the datum orbit) for bodies, which may form successful orbits about a central body. Bodies, approaching the datum orbit from within, with higher (negative) drifting rate than this value will fly away from the central body.

Equation (10),  $-\alpha = \text{Sin}^{-1} \frac{u}{V}$  gives the condition required for an orbiting body to have perihelion and aphelion in its orbit. This equation should be satisfied two times in every completed orbit. If the body is entering its datum orbit from outside, by the time it reaches its perihelion, drifting rate of the body attains a value of  $\alpha = \text{Sin}^{-1} \frac{u}{2V}$ . As long as this value is not reached, the body will continue to move towards the perihelion. That is, distance between the central and orbiting bodies continues to reduce. If the drifting rate exceeds  $\alpha = \text{Sin}^{-1} \frac{u}{2V}$ , the orbiting body will move towards the central body at a higher rate and spiral down into it, without ever attaining the condition required for perihelion. Even if the orbiting body is to enter the datum orbit at the point of perihelion, its drifting rate should not exceed this limit. Thus,  $\alpha = \text{Sin}^{-1} \frac{u}{2V}$  is the outer limit of drifting rate during entry (for a body entering the datum orbit from outside) for a successful orbit.

Considering the above limits together, to form a stable orbital motion, a planetary body has to enter its datum orbit with drifting rate between  $\text{Sin}^{-1} \frac{u}{2V}$  and  $-\text{Sin}^{-1} \frac{u}{2V}$  at the point of entry. Limit between  $-\text{Sin}^{-1} \frac{u}{2V}$  and zero is for those bodies approaching from inside the datum orbit. Bodies with drifting rate between  $-\text{Sin}^{-1} \frac{u}{2V}$  and  $-\text{Sin}^{-1} \frac{u}{2V}$  will have their aphelion in front of the entry point. When the drifting rate is equal to the critical value of  $-\text{Sin}^{-1} \frac{u}{2V}$ , the body will trace a circular orbit. Bodies with drifting rates between  $-\text{Sin}^{-1} \frac{u}{2V}$  and  $\text{Sin}^{-1} \frac{u}{2V}$  have their perihelion in front of their point of entry. Limits between zero and  $\text{Sin}^{-1} \frac{u}{2V}$  are for those bodies approaching from outside the datum orbit. From the point of entry, they can move only towards their perihelion. These stringent restrictions, in conjunction with restrictions on the magnitude of angle of entry (direction of approach as explained in next section), considerably lowers the number of bodies, those are able to form stable orbits and prevents profusion of planetary bodies about a central body.

Curvature of orbit and the tangential speed of a planetary body depend on its location on the orbital path. Centre of curvature at any point on the orbit is the focus of the orbital path. In real-motion, centre of curvatures for orbital motion on either side of median path, lie on the opposite sides of the median path. Curvature is zero at mid-points and increases as the body moves towards the aphelion or perihelion. However, while considering the apparent orbit, the curved path is assumed to close-in on itself to provide circular/elliptical nature, by assuming the central body in a static state and arbitrarily reversing the direction of one half of orbital motion. This is accomplished by the change of reference to a convenient frame from the real (absolute) reference frame. By doing so, each planetary orbit is made to appear as a closed geometrical figure around the central body.

### **Apparent angular motion of a planet:**

While a planet is performing its orbital motion about the central body, it is also orbiting around the centre of central body's orbital centre (galactic centre). Consider a planetary system as a single

unit (of revolving bodies about a central body) that is orbiting the galactic centre. Galaxies are spinning bodies but they have no orbital motion about any other body. They are static in space other than for small movements during their stabilization. By the time the central body completes an orbit around the galactic centre, every planet in the unit apparently loses one orbit each, about the central body. This provides an apparent loss of orbital motion to the planet. A planet apparently loses part of its orbital motion at a constant rate.

### **Orbits about a moving central body:**

It is unlikely that bodies of considerable sizes move away from a central body to enter into orbital path about it. All larger bodies, planets, have to come from outside the planetary system. Planets may enter into their orbits in any direction around a static central body. However, if the central body is moving (as is the case with all free bodies in universe), directions of approach of the planets are restricted. Following description is about planetary bodies approaching the central body from outside of their datum orbits. To make the explanation simpler, an apparent orbit is used to describe the actions.

All large bodies move at very high speed. (It is estimated that the sun moves in a circular path around the galactic centre at a relative speed of about 250000 m/sec, much greater than the relative speed of earth with respect to the sun, which is about 30000 m/sec, in its orbit). Relative speed between the central body and a planet trying to enter into an orbit depends on the relative directions of their motions.

Planetary bodies, approaching in opposite direction to the motion of the central body will find the interaction due to central force enhancing their present speed. Relative speed of the bodies will become too large for them to form a planetary system. Consequently, no planet that is approaching the central body in opposite direction to the direction to its own motion can enter into a successful orbit. Similarly, bodies approaching from the sides (all around) will be left far behind the central body. Such bodies have very little or no motion in the direction of motion of the central body. Hence, their relative speed is too large. They cannot have stable orbits. In order to enter into a successful orbit, a body has to approach the central body from the rear and nearly in its orbital plane. During such an approach, relative speeds of the planetary bodies with respect to the central body's absolute speed will be only a small fraction. Relative speed of the approaching body is with respect to the absolute speed of the central body.

A central body usually has a curved path as shown by line NOM in figure 10, where the direction of approach is shown with respect to an apparent orbit. A planetary body, approaching its datum orbit from the inner side of this curved path, will find that it has an additional relative motion away from the galactic centre. This is produced by the curvature of central body's path. Planetary body's drifting rate is enhanced by the curvature of central body's path. Additional relative motion will also enhance the radial motion produced by the central force. These factors prevent a body, approaching from the concave side of the central body's path to enter into an orbit (about the central body that itself is moving in a curved path).

Above factors leave only a small window, shown by APEC in figure 10 (width of the window shown in the figure is highly exaggerated), through which a planet may enter into successful orbit about a central body. This window is on the outer (convex) side of curved path and to the rear of the central body. It is somewhat conical in shape, with its apex towards the outer datum point. Girth of the cone restricts entry to the bodies, whose orbital plane can be gradually stabilized into central body's orbital plane. All planets, entering into successful orbit, enter through this window, which is further restricted by the limits of drifting rate. Therefore, there are no planets orbiting in opposite direction to central body's own orbital direction or having its orbital plane too far from central body's orbital plane. Direction of apparent orbital motion of a planet is the same as the direction of central

body's orbital motion about the galactic centre. Thus, all orbiting bodies in a planetary system move in the same angular direction and in planes not much different from central body's orbital plane.

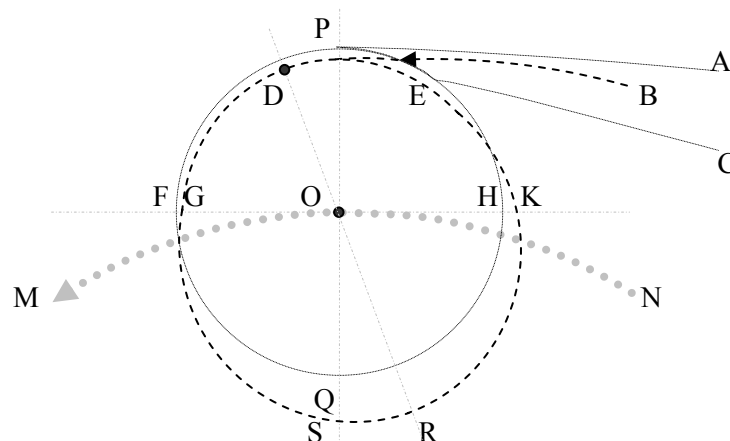


Figure 10

As shown in figure 10, O is the centre of apparent orbit. Black circle at O is the central body and the black circle at D is the planet at its perihelion. PFQH is the datum orbit corresponding to body's parameters. P and S are the datum points, where highest and least linear speeds of the orbiting body occur. Orbiting body may enter into the datum orbit anywhere through the conical window shown by shaded region between A and C. Position of perihelion of the orbit, D, depends on the point of initial entry, E, and the drifting rate. Greater the drifting rate, farther from the point of entry is the perihelion.

Only those planetary bodies, whose drifting rate at the time of their entry into orbital path, are within the limits  $\sin^{-1}(u \div 2V) < \alpha < -\sin^{-1}(u \div 2V)$  and whose direction of entry is through the permitted window can enter into a stable orbit about a central body that is itself moving in a curved path. Changes in the mass or speed of an orbiting body may change the size of its orbit, not its eccentricity and angular position. In order to change the eccentricity or angular position of an orbit, an external force has to be applied on the orbiting body to deflect it from its present course and change the deflection rate of V by an effective change to the drifting rate, while in the orbit.

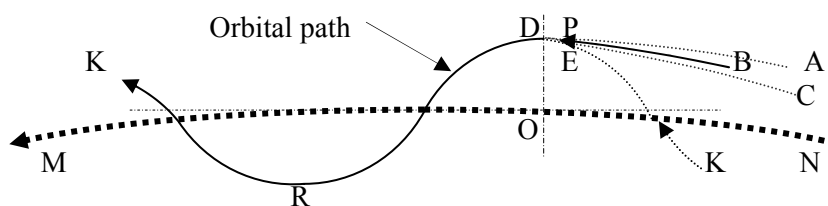


Figure 11

Figure 11 shows the entry zone for planets on their real orbital path. KDRK is the orbital path and APC shows the entry zone. This may be compared with figure 10. Entry window is from the rear and on the outer side of the median path. This arrangement ensures that all planets of a planetary system move in the same direction along with the central body, giving rise to similar angular direction of rotation to all apparent orbits of a planetary system.

Unlike planets, comets have very large and highly eccentric apparent orbits. Their periape occur within central body's path and highest absolute orbital speed occurs nearer to their apoapse. Hence, it

may be deduced that they enter their orbit from within their datum orbit.

## **Anomalies:**

### **Precession due to eccentricity:**

If there is a large difference in the masses of the central body and a planetary body, orbiting in highly eccentric orbit, difference between the linear speeds of the orbiting body during its acceleration and decelerating stages is considerable (action of an external force depends on the speed of a body [1]). This speed difference influence central force's actions. Such actions can apparently rotate (precess) an apparent orbit without changing its shape or size. Rotation of apparent orbit means forward/rearward shifting of real orbital path in relation to central body.

In real motions, both the central and the planetary bodies move about a median path. Perturbations of planet's path are more apparent and it appears to be its orbital motion. While the planet moves along with the central body, it is in front of the central body for half the orbital period (during its motion from outer datum point to inner datum point) and it is behind the central body for the next half the orbital period (during its motion from inner datum point to outer datum point). When the planet is in front, the central force acts to decelerate the planetary body and when it is behind, the central force tends to accelerate the planetary body. (Actions on the central body are of opposite nature). Inertial actions are slower and hence less effective in the direction of motion of a body. Hence, it takes longer for the planetary body to traverse the path from inner datum point to outer datum point compared to the other half. Longer time period causes larger radial displacement of the planetary body, taking it nearer to the median path. Planetary body's perpendicular distance from median path during this period becomes shorter than its distance in opposite direction during the next half of the orbit. This difference provides a resultant displacement of the orbital path towards the centre of central body's path. The planetary body, in its path is brought nearer to the centre of central body's path (galactic centre).

In an apparent oval orbit, there is only one point that is nearest to the focus. This point is the perihelion. If the apparent orbital path is displaced, such that another point in the apparent orbit comes nearest to the focus, it is as if the perihelion of the apparent orbit has shifted to the new point. As different points on the apparent orbit come nearest to the central body on successive orbits, perihelion of the orbit shifts along the apparent orbit and the apparent orbit of the body appears to rotate about the central body, in space. This precession is an illusion provided by displacement of 'point of nearest approach' of the bodies. In reality, no changes take place in the relative motions of the orbiting bodies, except that the point in space at which these bodies come nearest shifts along the perturbed paths. Magnitudes of the perturbations or their time periods are not affected.

If the orbital motion is considered with respect to the planet (central body, orbiting the planet), orbit of the central body will appear to precess in opposite direction. Apparent orbits of all planetary bodies with highly eccentric orbits have appreciable precession about their central bodies. In case of a central body, having two or more such planetary bodies in the apparent orbits around it, the central body has different rates of precessions simultaneously, a different rate of precession with respect to each of the planet. If the precession is linked to real motion of the body this is an impossible situation. Direction of this precession is the same as the direction of motion of planet in its orbit.

### **Precession due to curvature of central body's path:**

Apparent orbits are formed in space. Central body moves in a curved path. Consequently, as the central body moves in its curved path, the median path of the planet is required follow this curved path. Due to their relative motion (caused by the curvature of central body's path), median path of the planet tends to move outward from the centre of central body's path and with respect to the median

path of the central body. (For the time being, we may neglect the effect of remaining bodies of the galaxy on the planetary body). Median path of the planet tries to be straight, while central body's path curves. A shift in the median path of the planet introduces corresponding shift in the central body's path also. Consequently, the planet is on the concave side of the median path for shorter time compared to its existence on the convex side of the median path. Additional radial displacement in perpendicular direction, provided by the central force, brings the median path back to its original state. By doing so, the median path of the planet is shifted towards the centre of the central body's path (galactic centre). Shifting of the median path also shifts the 'point of their closest approach' in opposite direction, away from the galactic centre. This relative motion creates another type of apparent precession of the orbit. Direction of this precession is in a direction opposite to the orbital motion of the planet. This precession is an illusion provided by relative inward displacement of median path of the planet with respect to the central body's path (caused by the curvature of its path).

Two types of precessions, mentioned above, are in opposite directions. In cases of apparent orbits with low eccentricity, they, more or less neutralize each other. No resultant precession may be noticed over extended periods. In cases of apparent orbits with higher eccentricity, precession caused by the orbital eccentricity may be large enough to produce observable resultant precession of the apparent orbit in forward direction. If the eccentricity of the apparent orbit approaches zero, precession caused by the curvature of central body's curved path may become apparent over extended period as a rotation of the apparent orbit in rearward direction.

### **Perturbations caused by collisions:**

Wandering free bodies in open space may fall into the planetary bodies or into the central body during their attempt to form orbits around either of the bodies. A foreign body, falling on these bodies, brings-in additional matter content and work contained in it. Such additions are likely to modify orbital parameters of the bodies. Over extended period, in space, such modifications of orbital properties are very probable. Orbital motions of planetary bodies are also influenced by nearby bodies. These changes may be either temporary or permanent. An accurate picture of orbital motion can be developed only when all other bodies in space and their effects on the orbiting body are considered.

### **Electronic orbits:**

From the largest of stars to the smallest of fundamental particles, if a body has to orbit about another, it has to do so under the same principle and such orbital motions should obey the same physical laws. Any matter body with sufficiently large linear speed may orbit about a moving central body of (comparatively) appreciable mass. At first glance, it may appear that the topic of electronic orbital motion is inappropriate in this article. Reader may be rest assured that it is not so. Details on the mechanism of orbital motions of electrons in the atoms, about their nuclei, may be found in [1] the reference book.

Electrons are matter bodies with definite physical structures. In their stable orbital motion, central force (provided by apparent gravitational attraction) is the only force acting between them and the nuclei to which they are attached. Electrons, in the atoms, keep their attachments with the nuclei under the central force, provided by apparent gravitational attraction. Orbits of atomic electrons are located in a region, where the electromagnetic or nuclear forces have no effects. {Various forces mentioned are different manifestations of only one type of force in nature. It is the nature of action of a force that makes its class. [1]. Hence, we may say that the gravitational nature of force is prominent and nuclear and electromagnetic nature of the force is absent about an electron in stable orbital path about its nucleus}. During unstable periods, electromagnetic forces develop between nucleus and electrons to stabilize electrons' orbital motion. These stabilizing forces determine the size, angular and linear speeds, eccentricity and location of electronic orbital paths. It is the orbital motion, (in

addition to the repulsive electric field forces during unstable periods), which prevents an electron from spiralling down into atom's nucleus or flying away from it.

Since the electrons are too small and curved paths of their central bodies are within the electronic orbits, electronic orbits in stationary atoms appear to be real orbital motion around a central body. An electronic orbit is the nearest, a real orbit can resemble apparent orbital motion. Electronic orbits remain on the same side (outside) of the central body's path and deflection and drifting rates do not change directions. Electrons in the atoms also have apparent orbital motion about their nuclei. In these cases, the central bodies (corresponding deuteron, paired to each of the electrons) are anchored to the nucleus and hence they are unable to have independent orbital motion of their own, other than that provided by spin motion of the nucleus. All planetary laws are applicable to orbiting electrons, with modification as required due to controlled motion of the central body and the orbits being placed outside the central body's path.

## Conclusion:

Apparent orbit of a planet is an imaginary figure (in space), developed from appearance of planetary motions to an observer (assumably) based on the central body. The central body is assumed to be static in space. In reality, a planet moves along with the central body in a wavy path about the path of the central body. A real orbital path does not form a closed geometrical figure. A planet enters into its orbit straight away as it approaches the central body; there is no gradual development of orbital motion. All planets and satellites in a planetary system orbit in the same direction, which is same as central body's orbital path about the galactic centre. Direction of entry of planetary bodies is limited within extremely small range. In order to enter a successful orbit, a planetary body has to approach the central body in (almost) parallel direction to its path at the right distance away and from the rear of the central body. Right distance is determined by speed and mass of the planetary body.

'Kepler's planetary laws' and other laws on planetary motions are formulated with respect to the apparent and imaginary orbital motion of the planets around a static central body. It is done by manipulating orbital parameters to suit the observation. It is currently believed that experimental evidences on the validity of Newton's laws of motion and also on the theory of universal gravitational attraction are provided by the laws of planetary motion and the observed parameters of earth's orbital motion, as applied to this apparent orbit. Using these evidences, which are based on apparent parameters of an imaginary orbital motion, to prove validity of a theory is unscientific.

## References:

- [1] Nainan K. Varghese, *Hypothesis on MATTER* (second edition), (2008).  
<http://www.booksurge.com/Hypothesis-on-MATTER-Second-Edition/A/1419689789.htm>
- [2] Nainan. K. Varghese, ARTICLES, <http://matterdoc.hdfree.in>

\* \*\* \*\*\* \*\* \*