Gravity, Rosettes and Inertia

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Abstract and purpose

• **Our objective is to show a new way to sum the gravitational forces of the planets to calculate the solar orbit and its wobble. You see the wobble of the Sun caused by the much smaller masses of the planets. You are primed to see that any object which experiences a force is resisted by the masses of the planets, by the mass of the Sun and the mass of the Cosmos. Your vision, metaphor and paradigm has been extended to see that this is inertia.**

Keywords

• **Orbits, binary systems, rosettes, orbital lobes, solar wobble, stellar wobble, Cosmic wobble, gravity, inertia, origin of inertia**

Introduction

The Sun and planets are a dynamic unit. When the planets move they cause the Sun to move. We never see or hear about the wobble of the Sun because the Sun wobbles in the plane of planets where we look at the Suns equator. The wobble of the Sun would be most visible when looking down on the Sun's poles. First, we will look at the Sun and Earth as a binary system. They orbit around their common center of gravity so that *the Sun wobbles.* When we sum the forces of gravity of all the planets in the solar system, we see the Sun has a complex wobble and some of the planetary orbits have lobes. These wobbles and lobes are missed when you consider the Sun to be the **unmoving center** of our solar system.
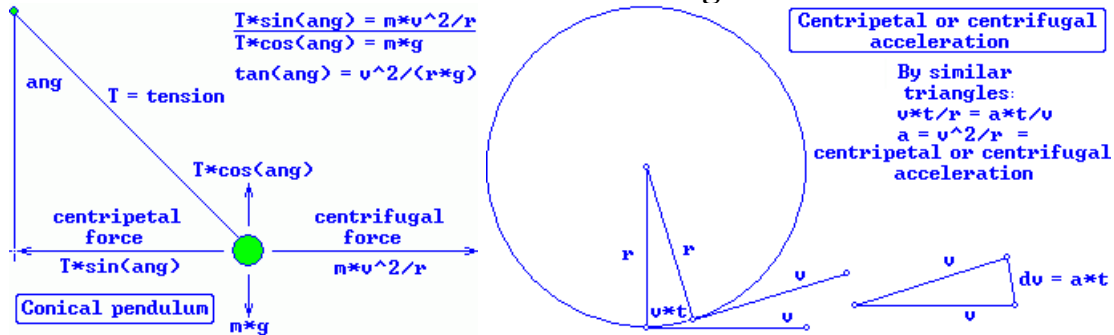
Kepler's third law

$m*vt^2/r = G*m*M/r^2$, *centrifugal force equals gravitational force*. This is just another way of writing Kepler's third law. **M** and **m** are mass. **vt** is tangent velocity. **G** is the gravitational constant. **r** is the radius apart. The period of a circular orbit is **p**.

$p = 2*pi*r/vt$, therefore $vt^2 = \{4*pi^2*r^2/p^2\}$

$m*\{4*pi^2*r^2/p^2\}/r = G*m*M/r^2$, substituted for vt^2

$4*pi^2*r^3 = p^2*G*M$, collected terms. The cube of the radius is proportional to the square of the period. This is Kepler's third law but we will usually use it in the "centrifugal force equals the gravitational force" form. This equation and the idea of conservation of energy are both indubitably correct and are central to our arguments.

Click to animate! Centrifugal force

$$T*\sin(ang) = m*v^2/r$$
$$T*\cos(ang) = m*g$$
$$\tan(ang) = v^2/(r*g)$$

T = tension

ang

T*cos(ang)

centripetal force
T*sin(ang)

centrifugal force
m*v^2/r

Conical pendulum

m*g

Centripetal or centrifugal acceleration

By similar triangles:
v*t/r = a*t/v
a = v^2/r =
centripetal or centrifugal acceleration

r   r   v   v*t   v   dv = a*t   v

When gravity exerts a center seeking centripetal force, inertia opposes this deviation from straight line motion with a center fleeing centrifugal force. The centripetal gravitational force equals the inertial centrifugal force along a circular orbital path. For every action there is an equal but opposite reaction. A conical pendulum or a weight on a string is held out in its orbit by centrifugal force. Slinging a rock on a rope, around in a circle, demonstrates this centrifugal force which can easily be measured with a spring scale used by fishermen. You and the rock are masses in a binary system, in orbit across from each other around a common center of mass with a common orbital period. The center of mass or **barycenter** is always someplace along the rope between you and the rock. The centrifugal forces are with respect to the barycenter not the distance between the masses. Your centrifugal force at your distance from the barycenter equals the centrifugal force of the rock at its distance from the common barycenter equals the tension in the rope between the two masses. If the rope is cut or released both the centripetal and centrifugal forces become zero. The rock continues on its inertial path. You continue on your inertial path determined by your momentum prior to release, that is, tangent to the circle at the point of release. The two paths are in opposite directions. Reality is defined by simple experiments like this one. I suspect Newton would have done something like this experiment when he was in his twenties working on gravitation in the sixteen sixties. He would have known this is equivalent to Kepler's third law.

Orbits

Orbits are so intertwined with centrifugal force that they are usually inseparable. When something moves in a circular orbit, satellites around the Earth, planets around the Sun, electrons around protons, light around black holes, *the centrifugal force equals the gravitational force of attraction* or *the centrifugal force equals the electrostatic force of attraction.* The centrifugal force between two orbiting bodies which tries to pull them apart has to be equal, at some points in their orbit, to the attractive force which tries to hold the two bodies together, or the bodies can not orbit. If the centrifugal force is greater than the attractive force then the bodies will drift apart. If the centrifugal force is less than the attractive force then the bodies will drift together. Only the equality, the equilibrium state between the forces and the two masses can endure. The evidence of equilibrium is the orbit. The bodies drift apart with a constant velocity in the expansion of the universe and drift apart or together with a variable velocity in elliptical orbits.

In the solar system each planet imposes an additional gravitational and centrifugal force, barycenter and orbital period on the Sun. The angle and force between the Sun and planets can be expressed as **x**, **y** and **z** forces, summed and applied to the Sun so that the Sun also moves. There is no unmoving center. *All the masses always move*.

Centrifugal force of the Earth = Centrifugal force of the Sun = Gravitational force

$$m_e*v_e^2/r_e = m_s*v_s^2/r_s = G*m_e*m_s/(r_e+r_s)^2 = 3.54146E22\_kg*m/s^2,\text{ when } cd = (r_e+r_s) =$$

149.5817E9_m.

G is the gravitational constant. **me** and **ms** are the masses of the Earth and Sun. **re** and **rs** are the distances to the barycenter. **cd = (re+rs)** is the center distance which varies from perigee to apogee. **ve** and **vs** are the orbital velocities around the barycenter.

If **cd** is greater than **149.5817E9_m** then the centrifugal force is greater than the gravitational force. If **cd** is less than **149.5817E9_m** then the gravitational force is greater than the centrifugal force. **cd** varies from the **Earth's perigee = 147.098070E9_m** to the **Earth's apogee = 152.097700E9_m**.

- The **left term** is the centrifugal force of the Earth around the Earth-Sun barycenter.
- The **middle term** is the centrifugal force of the Sun around the Earth-Sun barycenter. The Sun also moves. This term is always neglected in over simplifications. *Where is it not neglected?* This term is necessary to understand *inertia, force = mass*acceleration*.
- The **right term** is the gravitational force between the Earth and Sun across the barycenter.

The Earth and Sun both orbit at different distances about the same point with the same orbital period. That point is the barycenter of the Earth-Sun system. The three forces are along a line through the barycenter. If the forces had a propagation delay then the forces would pull on where the objects used to be and not be along this line. The forces would not be in a line they would form triangles. Energy would not be conserved. The orbits would not endure. See Van Flandern.

Seeing the Sun and Earth as a binary system

We are using the Earth and Sun as an example. A binary system is defined by the variables of mass, distance to the barycenter, tangent velocity around the barycenter and center distance between the masses.

1. **ms*vs = me*ve = 1.77887E29_kg*m/s**. Their *angular momentums are equal*. This uses mass and orbital velocity.

2. **ms*rs = me*re = 8.93426E35_kg*m**. Their *mass distance products are equal*. This is the balance equation used in scales.

3. **vs/rs = ve/re = 1.99106E-7_1/s**. This is **(1)/(2)**.Their *angular velocities and orbital periods are equal*. The angular velocity in radians per second is the orbital velocity of the object divided by the distance to the barycenter. The angular velocity of the Sun and Earth and their orbital periods are the same since they are a binary system.

   centrifugal force of the **Sun** = **centrifugal force** of the **Earth**
4. **ms*vs^2/rs = me*ve^2/re = 3.54184E22_kg*m/s^2**, this is **(1)*(3)**. Their gravitational and *centrifugal forces are equal*.

Distance and velocity

We can calculate the distance to the barycenter of each of the bodies if we know their masses and their total distance apart. In all binary systems, the distance, velocity and mass are related by ratios and products. The Sun's ellipse and Earth's ellipse share a common focus at the Sun-Earth barycenter and a common orbital period. The elliptical orbits of the Earth and Sun have an eccentricity of **e = 0.0167**. When the Earth is at perigee, the Sun is at perigee on its much smaller ellipse. When the Sun is at apogee, the Earth is at apogee on its separate ellipse. The Sun at **rs** and Earth at **re** are opposite each other across the barycenter. **cd = re + rs = center distance**. The center distance is the distance between the Earth and the Sun.

5. **re + rs = cd = 149.598E9_m,** the distance between the bodies **cd** changes constantly in an elliptical orbit but not in a circular orbit. When **cd** changes **re, rs, ve** and **vs** and this group of equations also change. **cd** is here shown as the average distance, the **au** only for convenience in working this example, since it should be emphasized that it is a distance which varies from perigee to apogee. An **au** *astronomical unit* is the unvarying average distance between the Earth and the Sun.
   {rs*ms/me} + rs = cd, substituted for **re = rs*ms/me** from **(2)**.
   rs*(ms+me)/me = cd, collected terms.

6. **rs = cd*me/(ms+me),** the distance from the Sun-Earth barycenter to the center of the Sun. The Sun is not stationary. The Sun orbits around the Sun-Earth barycenter at this distance. The planetary data shows this as the *solar wobble distance*.
   me = 5.9722E24_kg, the Earth's mass.
   ms = 1.98843E30_kg, the Sun's mass.
   rs = 149.598E9_m *5.9722E24_kg /(1.98843E30_kg +5.9722E24_kg) = 449312_m, this is the offset from the solar center which the Sun orbits around with respect to the Earth. The solar radius is about **6.955E8_m** so this offset is about one part in **154.78** of the solar radius, quite close to the center of the Sun. The Earth by itself does not cause much of a wobble in the Sun's orbit but with the action of all the planets there is a considerable wobble in the Sun's orbit.

7. **re = cd*ms/(ms+me) = 149.59755E9_m**

8. **ve = 2*pi*re/period = 2*pi*re/(31556925.9747_s) = 29786_m/s,** the Earth's orbital period around the barycenter is one year as is the Sun's with respect to the Earth.

9. **vs = ve*me/ms = ve*rs/re = 0.08955_m/s,** from **(1)** or **(2)**. Galileo was wrong, the Sun does move with respect to the Earth, but not fast. This is **3.5** inches per second or **0.2** miles per hour.

Click image to animate!
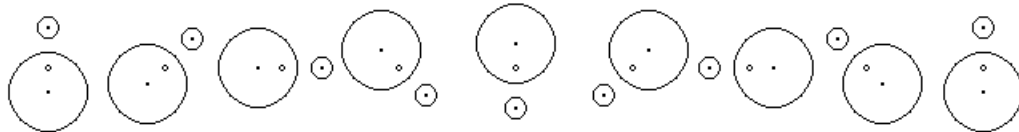
Wobbles and a donut

When the barycenter is inside a member of a binary system, as it is in the animation, then its motion is a wobble. The Earth appears to wobble because of the Moon. The Sun appears to wobble, because of its planets, when seen from its poles. We see the Sun from its equator where we can't see the wobbles directly but we might detect the Doppler-shift in the Sun's light caused by these wobbles. Wobbles can also reveal planets around other stars by the Doppler-shift in their stars light which are most pronounced when seen from their equator or planetary plane edge-on.

There is a different barycenter and wobble in the Sun for each planet. Galaxies wobble. The universe wobbles. The Sun orbits about all of its different centers of mass of all the planets simultaneously. This is a complex pattern of movement. Only the Sun-Jupiter barycenter is outside the surface of the Sun. The Sun makes offset from its center orbits or wobbles around its barycenter for all the planets except for Jupiter. The wobbles have the orbital period of the planets. The Sun makes a donut, not a wobble in the sky, in its orbit with Jupiter. This barycenter is outside the radius of the Sun. The donut has the orbital period of Jupiter. The donut is seen from the solar poles against the background of the fixed stars. If the Sun and Jupiter orbit around their common barycenter then in some real way the Earth orbits with Jupiter. *In what way?*

1. The sum of the **x**, **y**, and **z** components of the forces of the planets, when divided by the mass of the Sun is an acceleration.
2. The Suns acceleration over time is a velocity in a certain direction.
3. The direction, velocity and location of the Sun with respect to the background stars varies as the Sun loops around.
4. These movements produce huge tidal forces in the Sun. These tides may produce solar tsunamis.
5. The tides suck energy from the Suns rotation. Over billions of years the Sun has lost much of its angular velocity accounting for its slow rotation. As the Sun slows in its rotation, the Sun recedes in its orbit, the planets receded in their orbits.
6. This is a solar system wide Hubble like expansion.

The expansion of the universe might be applied to the Earth's orbit

The Earth's orbit is **r = 149.497E9_m**. The year is **31556926_s**. The age of the universe is **age = 4.73353E17_s**.

Then **1/age = 2.11258E-18_m/(s*m)** meters per second per meter is the velocity of expansion of the universe per meter. For the Earth's radius we multiply by **r**.

**r/age = v = 3.158E-7_m/s* 1_year = 9.966_m/year** the Earth's orbit expands at **10_m per year** due to the expansion of the universe within our solar system, if this expansion exists. Unfortunately, this is an undetectable amount.

The Moon's orbit is **r = 384403000_ m**

r/age = v = 8.1208E-10_m/s* 1_year = 25.63_mm/year the Moon's orbit expands at **26_mm per year** due to the expansion of the universe within our solar system, if this expansion exists.

The Apollo missions to the Moon left behind a laser reflector so that the round trip of laser pulses may be timed and the distance to the moon calculated. The moon is receding from the Earth, due it is said to tidal drag, at **38_mm** per year. Who knows? Friction loss due to tidal drag is hard to estimate. It is possible that **26_mm** of this expansion may actually be due to a Hubble expansion in the solar system.

Click image to enlarge!
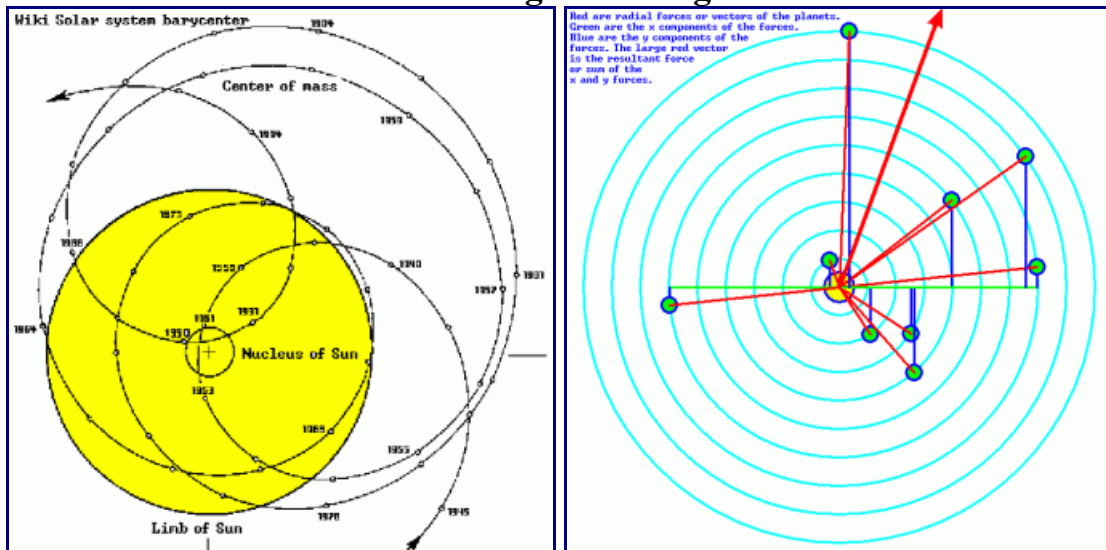
- **First,** on the left. This is a figure from Wiki which shows the Sun. The black line is the path and

location of the Sun over time. See Barycenter in astrophysics and astronomy. See the "Barycenter of the solar system" at Gravity simulator. The Suns movement is the vector sum of the forces of the solar system and galactic and other forces from outside our solar system. The Sun moves with respect to the background stars, galaxy and quasars as well as the planets.

- **Second**, This uses the **radial angles** and the **forces** of all the planets.
  - Forces are **vectors = (red)**. You can add the **x**, **y** and **z** components of vectors or forces.
  - **x = radial force*cosine(angle) = (green).**
  - **y = radial force*sine(angle) = (blue)**.
  - The summation of the **x** and **y** planetary forces is the resultant force that the Sun experiences from the planets. This resultant force causes the Sun to **move = (large red arrow)**.

The Sun is also moved by many other forces from outside the solar system but none are included in these calculations. The rosettes which follow were calculated in this way. We use the fact that both the Sun and planets move.

### Click to enlarge rosettes! When planets move the Sun moves.
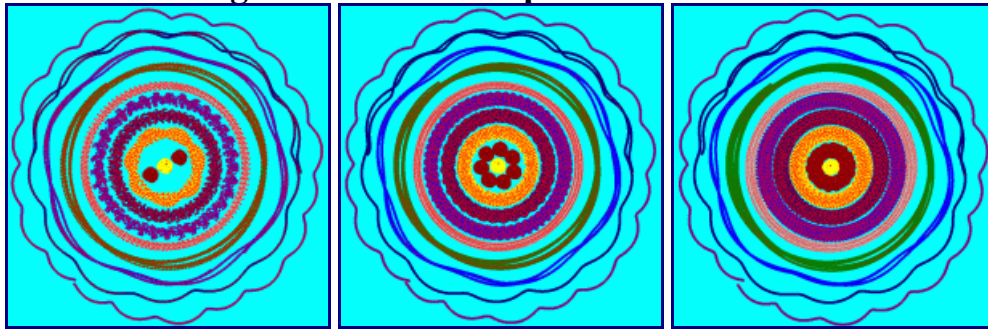
Each of these rosettes shows the position of the Sun and planets against the background stars, looking down on the north pole of the Sun. The radial movement of the Sun and the radial movement of the planets are to scale. The radius of the orbits of the planets are not to scale. The depth of the lobes reflects the movement of the Sun. The petals or lobes are exaggerated when we put them on a page rather than draw them to scale with Pluto's orbit being **8491** times the solar radius. The lobes disappear in the scale of the planetary orbit as the size of the Sun's movement becomes miniscule compared with size of the planetary orbits. This is over a period of **247.7** years, the orbital period of Pluto. We look at the position of the Sun and planets **2, 7** and **14** times per Mercury year of **88.023** days. Mercury makes **1027.8008** orbits around the Sun for every orbit of Pluto.

- **First on the left,** we see the position of the planets as a dot every **44.01** days for **2055** dots per planet. Each dot is the position of the planet at that moment. The many dots merge into lines. Mercury has a circular orbit around the Sun but we capture our pictures of Mercury twice in its orbit when it happens to be in the two little dark circles. This gives the effect of a strobe light freezing periodic motion. Mercury has its orbital motion frozen since we have fixed our strobe-light-periodic-views on its orbital period. The position of Venus is always someplace in the odd seven lobe ring at these times. In the figure, there is a hint of lobes on the inside of Earth's orbit and on the outside of Mars' orbit. The planets are considered to have circular orbits with respect to the Sun but the Sun also moves. The planetary orbits and solar orbit are seen as lobed with respect to the background stars because they move together against the practically unmoving background of the stars. The path of the planets appear somewhere in these patterns when the position of each planet is recorded as a dot every **44.01** days. They demonstrate a non-integer harmonic relationship.

- **Second**, we see the position of the planets as a dot every **12.57** days for **7194** dots per planet. Mercury has the pattern of **7** little dark circles.

- **Third**, we see the position of the planets as a dot every **6.28** days for **14389** dots for the Sun and each of the nine planets or **143890** dots. The harmonic information, from the inner planets, is lost in a sea of dots.

Click to enlarge solar wobble!
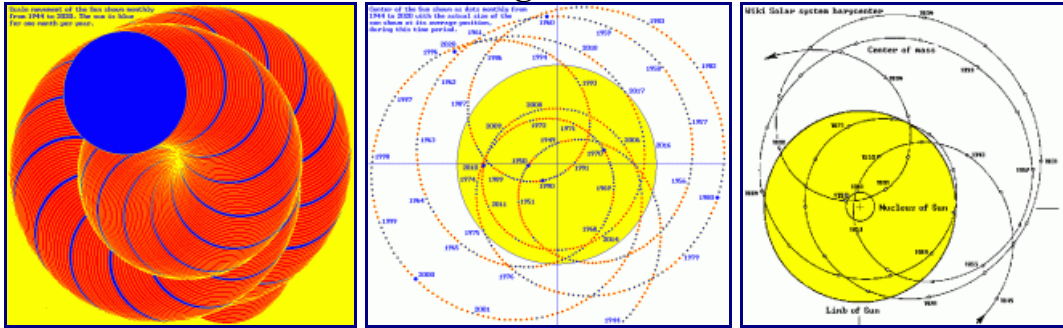
- **First**, this blowup shows the path of the solar disk at the center of the rosettes. The Sun's disk is shown as blue for a month per year from **1944** to **2020**. This is a scale drawing of the solar disk and the movement of the Sun.

- **Second**, The same period and path of the Sun is shown, not as a monthly solar disk, but as a series of monthly dots. These dots shows the path of the center of the Sun. The Sun is seen to orbit around an average position with respect to the background stars. The Sun's orbit has lobes like the planets. This figure duplicates the start of the time period seen in the figure from Wiki for confirmation of our calculations. The movements of the Sun are similar in both figures. The Suns orbit is obviously not circular or elliptical. This complex orbit is caused by the planets. The Sun must experience huge tidal forces and friction losses to its angular momentum, to move like this.

- **Third**, This is the Wiki graphics for comparison.

How this works

1. The mass and orbital period of the planets and other data is recorded from a Planetary Ephemeris. The orbital period of the planets is considered constant and their orbits circular.
2. The angle and distance from the Sun for each of the planets was recorded for a certain day.
3. The gravitational force between the Sun and each planet was calculated.
4. The **x** and **y** components of the forces of all the planets were summed yielding the **x** and **y forces** on the Sun.
5. The **z** axis is omitted since the Sun and planets orbit nearly in a plane, .
6. The sum of these forces when divided by the mass of the Sun yield **x** and **y accelerations** of the Sun.
7. The accelerations were multiplied by the duration of the period of observation in seconds, **44.01** days is **380246** seconds, yielding an **x** and **y** solar velocity.
8. This is the velocity added by the solar acceleration.
9. The Sun also has a previous **x** and **y** velocity from the prior calculation which must be added to this new velocity from the acceleration.

10. The new acceleration changes the direction and velocity of the Sun. The Sun is considered to move with the sum of these velocities to a new position for each observation.
11. **On the graphics** each positional dot is a tiny circle filled with a color and outlined by another color.
12. The circles overlap leaving behind the outline colors.
13. The Sun is a red circle outlined in yellow which leaves behind a yellow donut as it loops around.

The circular path of the Sun only comes from the summation of the **x** and **y** components of the planetary force vectors as the planets orbit. ***The Sun orbits as the planets orbit.*** This is surprising and there is a lot more to this. The central force of gravitation allows rotation in the solar system and the Cosmos. The normal condition for gravitational and electrostatic systems is to orbit, not to fall together. Orbits can be forever. ***What you see depends on the metaphors you use and the paradigms you follow***.
As the Sun moves, it drags the planets with it, leaving some of them with lobed orbits. This may look crazy but ***it is astonishing that we did not see this in elementary school***.

The planets move the Sun. The planets move with the Sun

Their orbital periods and velocity around the Sun do not change. Radial movements cause the rosettes. The rosettes are only seen with respect to the fixed reference of the background stars. The center of the Sun loops around a variable radius of about two solar diameters or **14E9** meters. The lobes on the planets move the same radial distance. The orbital radius of Pluto is **6E12** meters. **6E12/14E9** is **480** so the lobes on Pluto's orbit would be invisible at this scale. When you can see the whole orbit the lobes are too small to see unless they are greatly magnified. There are **20** lobes in Pluto's orbit because the Sun makes **20** orbits for each orbit of Pluto. Neptune has about **13** lobes. Uranus has about **6** lobes. Saturn has about **3** lobes. Jupiter has **1** lobe. Its path looks like a ring but it does move back and forth with the Sun. The lobes on the planets are synchronized with the orbit of Jupiter and the Sun.

These calculations and graphics were created with a [Liberty Basic](#) program. Basic is easy to read since it is text and easy to translate into other computer languages. This is the [Solar Wobble Text](#) file of the program. It may be run with the Basic editor.

Astronomers calculate the orbital parameters of extra-solar planets from the visual wobble of a star or the Doppler frequency changes as it approaches and recedes from our point of view. When tiny distant Pluto moves, the Sun also moves, as they are a binary system. When the Sun moves, the Cosmos moves, as they are a binary system. ***This is how inertia works.***

For every action there is an equal but opposite reaction. When you push something, you accelerate it to get it moving, something pushes back. It is the opposite acceleration of the mass of the universe which pushes back. ***What else could there be to push back?*** Everything is connected. Everything is a part of a binary system with the universe. Inertia is the acceleration dependant reaction of the observable universe. The observable universe is that part of the totality of everything which has a knowable radius and mass. I like to call it the Cosmos.

Binary systems show how inertia works

The binary system consists of a dumb-bell of two masses. The mass of the universe is considered as a point at one end of the dumb-bell. A solar mass star is considered as a point far out at the other end of the dumb-bell. Both masses move. There are two each of masses **m**, tangent and radial velocities **vt** and **vr** and distance to the barycenter of the system, **r** or **dbc**. Binary systems use several of their ratios and products.
(1) ms*vts = mu*vtu, their ***orbital momentums are equal***. The **s** is for a star near the edge of the Cosmos. The **u** is for the universe or Cosmos.

(2) ms*rs = mu*ru, their ***mass times distance products are equal*** and balanced.
rs = .9*c*age = 1.278E26_m. The star is at **.9** the radius of the Cosmos.
ru = ms*rs/mu. You can see the derivation of the radius and mass of the Cosmos in the black hole paper,
ru = ms* .9*c*age* G/(c³*age), substituted values for **rs** and **mu.**
ru = ms*.9*G/c² = 1328_m, is the distance from the center of the Cosmos, to the barycenter of the star-cosmos system. The barycenter of the system is close to the center of the Cosmos because of the huge mass ratio even though the star is near the perimeter of the Cosmos. When a force moves the star one way the mass of the Cosmos moves the other way a very small amount. They are on opposite sides of the barycenter, of a binary system, which can be thought of as a lever and fulcrum.

(3) vts/rs = vtu/ru, This is **(1)/(2).** Their ***angular velocities and orbital periods are equal*** for both bodies in a binary system.

Centrifugal forces

(4) ms*vts²/rs = mu*vtu²/ru, This is **(1)*(3).** Their ***centrifugal forces are equal***. Centrifugal force exerts its force in a radial direction perpendicular to the tangent velocity **vt** of its mass. This is mass times a radial acceleration. There is acceleration because the mass is changing directions in deviating from a straight line as it follows a circular path. This is a radial deflection and acceleration. This is the same geometry as the Biot-Savart law. See Paul Marmet.

Using radial velocities in an expanding system

ms *rs/age = mu* ru/age, This is **(2)** multiplied by **1/age**.
vru = ru/age = 1328_m/age = 1328_m/4.73E17_s = 2.8E-15_m/s, this is the radial velocity of the Cosmos with respect to the barycenter of the star-cosmos system.
vru *age = ru, the distance to the barycenter equals the radial velocity times the age of the Cosmos.
vru = ru/age so **vru/ru = 1/age = Hubble's constant** = the angular velocity.
vrs = rs/age = .9*c*age/age = .9*c, this is the radial velocity of the star with respect to the barycenter of the star-cosmos system.
vrs *age = rs, the distance to the barycenter equals the radial velocity times the age of the Cosmos.
vrs = rs/age so **vrs/rs = 1/age = Hubble's constant** = the angular velocity.
The star is at **.9** the radius of the Cosmos.
It has a radial and tangent velocity of **.9** the speed of light. Since it has a radial and tangent velocity, it is spiraling out, like everything else in the Cosmos.

(5) ms*vrs = mu*vru, collected terms. Their ***radial momentums are equal*** in an expanding system.

Coriolis forces

(6) ms*vrs*2/age = mu*vru*2/age, multiplied **(5)** by **2*angular velocity = 2/age**. Coriolis force exerts its force in a tangent direction. This is perpendicular to the radial velocity. Their ***coriolis forces are equal***. These are two equal but opposite Coriolis forces. This is mass times a tangent acceleration.

(7) vrs/rs = vru/ru = 1/age = Hubble's constant. This is **(5)/(2).** The radial velocity/distance are equal. This is the definition of Hubble's constant.

Tangent deceleration force

(8) ms*vrs^2/rs = mu*vru^2/ru, This is **(5)*(7).** Centrifugal force is a radial outward force **mass*vt^2/r** but this is **mass*vr^2/r** which is perpendicular to centrifugal force. Their *tangent deceleration forces are equal*. This is a tangent deceleration force in an expanding Cosmos.

ms*vrs/age = mu*vru/age, substituted for **r = vr * age**. This is mass times a decreasing acceleration. This is half the Coriolis force and in the opposite direction. It cancels half the Coriolis force. There is a decreasing acceleration because it decreases with age and because the mass is changing direction in going from a smaller circular path to a larger circular path, to a more straight line path, as the radius increases as the Cosmos expands. This is a tangent deceleration force. Their tangent deceleration forces are equal and decrease as the Cosmos expands and slows down in its rotation.

Force summary

Centrifugal force exerts its force in a radial direction, in a direction perpendicular, to the tangent velocity **vt** of its mass. Tangent acceleration force exerts its force in a direction tangent to a circle, in a direction perpendicular to the radial velocity **vr** of its masses. In the expanding Cosmos, **vt = vr**, *everything is expanding and rotating and everything is spiraling out*.

The two centrifugal forces and one gravitational force are equal. The two Coriolis forces are equal.
force s = force u, the centrifugal forces or Coriolis forces are equal but opposite. **force s** is a local force.
force u is the cosmic force inertia, the reaction of the Cosmos. Force equals mass * acceleration, so
ms*as = mu*au, the mass of a star is **ms = 1.9E30_kg** and **as** is the acceleration of the solar mass star and
mu = c^3*age/G = 1.912E53_kg is the mass and **au** the acceleration of the Cosmos.
au = as *ms/mu = as *(1.9E30_kg/1.9E53_kg) = as *(1E-23), the acceleration of the Cosmos in reaction to the star's acceleration is microscopic. When a force is applied to the star, the star is accelerated. The Cosmos mirrors this force with an equal but opposite force. The Cosmos has its own tiny acceleration for the forces, since accelerations are proportional to mass. These tiny accelerations over time produce a velocity. The Cosmos mirrors these movements in the same way the Sun mirrors the movement of the planets. *When a planet or a star or anything moves, the Cosmos moves*.

distu*rs = dists*ru, dists = 1_m, variables **distu** and **dists** are the distances that the Cosmos and the star move. **ru** and **rs** are the length of the levers, across the fulcrum from each other or across the barycenter from each other. The angular movements are equal but the radial lengths of the levers are vastly different.
distu = dists*ru/rs = 1_m*1328_m/1.278E26_m = 1.04E-23_m, or
If the star moves **1_meter,** then the Cosmos moves in the opposite direction, across the barycenter, **1.04E-23_meter.**

Newton had the idea that the mass of a body may be considered to be concentrated at a point at the center of the body and that gravitational forces can be considered to act between these points. Concentric shells of mass may be considered to be concentrated at a point, in the center of the shells, for a body outside the shells. Concentric shells of mass cause no resultant force on a body within static shells. For a body within the shells, this is true only for static shells. This is not true for expanding shells or for an expanding Cosmos.

As the objects in the Cosmos move, like the planets in the solar system, the center of the expanding concentric shells of mass of the Cosmos traces the sum of their movements around the barycenter of the Cosmos. The movement of the Cosmos around the barycenter of the system uses the same mechanics as the movement of the Sun on its wobbly path around the barycenter of the solar system. The movement of the Cosmos explains inertia.

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