Why is the moon always facing the Earth with the same side?

described by using
classical physics.

T. De Mees - thierrydm @ pandora.be

Abstract

Many different explanations are found in general literature and the Internet for the phenomenon that the moon is always facing the Earth with the same side. All of the websites pretend to know one or the other qualitative effect. Terminologies that are used as: tidal force, tidal lock, the tidal bulges, etc... don't mean anything by themselves. None of the writers explain it quantitatively nor qualitatively in a satisfactory way.
In this paper, I will quickly overview the most common theories and evaluate them. I show that there is not any gravitational possibility left for explaining this phenomenon. Further, I will explain the origin of the oscillations of the moon that makes the Moon showing about 60% of its surface instead of 50%. Also this can only be originated by non-gravitational physical laws.

Keywords: Moon – Earth – Sun – orbit – tidal force – tidal bulge.
Method: Analytical.

1. Some strange theories found on the Internet.

The reason why the moon always has the same side facing the earth seems to be a great mystery. But the explanations I found for it are rather disastrous.
Agreed, there are many possible implications and the explanations all sound nice, even if no one can really understand the details of them.

- Some say that the Earth's ocean tides are making the Earth's shape oval, and slightly behind in time to the position of the moon, so that the Earth is boosting the Moon's spin.
- Some say that the moon is not homogeneous nor perfectly spherical and that the Earth attracts the heaviest part of the Moon (or the bulged part) more than the rest of it. So, the heaviest part would be the one that is facing the Earth.
- Some talk about the tidal effect, the tidal force, the tidal locking and so on. But none of them come to a clue.

2. Is one of these explanations correct?

2.1. The oval Earth.

How could the oval Earth influence the Moon? It is a nice thought, but it is wrong. As we know, every physical mass can be reduced to its gravitation centre (or that of the system Earth-Moon) if we analyse pure linear Newtonian

gravitation. The shape and the homogeneity or heterogeneity of the object is independent from this universal property. Even oval, it always will be possible to reduce the gravitational effect of the Earth back to one point. Since the Earth, even oval, is quite symmetric, the position of the gravitational centre never changes significantly. Even when the Earth is asymmetric, the property remains.
A gravitational point does not have any orientation at all and can never exert a momentum upon the Moon.

2.2. The oval Moon.

The same reasoning as in 2.1. can be made. As well the Moon's as the Earth's gravitation can be reduced to one point. If the Moon has a bulge, the absolute changes of Moon's orientation during its spin motion will not change the fact that the gravitation centre will remain constant and is not able to exert a momentum.
Thus, it was again a very nice thought, but wrong again : since the Moon can be reduced to one point in Newtonian gravitation, there is no torque possible due to differences in density or due to bulges. No torque means : no preferred side of the Moon towards the Earth.

2.3. "Tidal forces" generating an absolute rotation of the Moon – our detailed screening.

I don't like the term "tidal effect" or "tidal forces" for cosmic use because the effect whereto authors refer is not comparable with the tides of the oceans. The terminology "tidal" for the oceans means the attraction -by the Moon an the Sun- of the oceans that are at a certain latitude on the Earth[3]. The tidal attraction hasn't any effect at the equator itself. See the explanation in my paper : "*On the Tides' paradox*".
What is meant by the terms "tidal effect" or "tidal forces" can only be compared with the equatorial "conveyor belt"[3] of the oceans. Since the use of these terms is wrong, I will replace the term "tidal effect" by "(gravitational) divergence effect" and the term "tidal forces" by "(gravitational) divergence spin (effect)".
The "divergence effect" on the Moon works as follows.
It is well known that when the Earth attracts the Moon, and the latter is orbiting in (more or less perfect) circles due to gravitation. Though, this property is a geometrical property and not a gravitational one!

Description of the orbital motion : let us take an object with a certain velocity v, under a force F that is <u>always</u> perpendicular to v.

It can be proven that this motion will result in the description of a circle with a radius R .
The relationship is purely geometrical : $F = m\, v^2 / R$.

The same happens between the Earth and the Moon : the orbit is circular (or can be slightly elliptic), and a certain radius R can be found that is directly related to the force F and the velocity v of the Moon at the place R.

Since the force is given by the gravitation equation of Newton : $F = G\, m\, M / R^2$, the equations can be put together and written as : $v^2 = G\, M / R$

But another effect is happening. The Moon-side close to the earth is laying in a smaller orbit that the Moon's centre's orbit. The side of the Moon that is the farthest away from the Earth comes in a larger orbit than the Moon's centre. Since the gravitational field of the Earth is diverging, the value of the force F is not identical for the whole Moon. Neither is the orbital radius R. Since there exists a strict relationship between F, v and R, the Moon will get, at each different radius another gravitational force, and also a different velocity v !

Let us call Δv the change of velocity due to the tidal force at the level of r , which is the radius of the Moon.

For the side of the Moon that is the closest to the Earth, the change of velocity is given by the equation :

$$(v+\Delta v)^2 = G\, M / (R-r) \qquad (2.1)$$

And for the opposite side of the Moon, the one that is away from the Earth, the change of velocity is given by the equation :

$$(v-\Delta v)^2 = G\, M / (R+r) \qquad (2.2)$$

We suppose that Δv and the radius r are more or less equal in both cases, which is correct to the first order.

$v+\Delta v = (G\, M / (R-r))^{1/2}$, which is equal to $v+\Delta v = (G\, M)^{1/2}\, R^{-1/2}\, (1 + r / 2R + 3r^2/8R^2 + \ldots)$ (2.3) and

$v–\Delta v = (G\,M\,/\,(R+r)\,)^{1/2}$, which is equal to $v–\Delta v = (G\,M\,)^{1/2}\; R^{-1/2}\;(\,1 – r\,/\,2R + 3r^2/8R^2 – ...\,)$ (2.4)

Former equations are based upon $(1 – x)^{-1/2} = 1 + x/2 + 3x^2/8$ ... and $(1 + x)^{-1/2} = 1 – x/2 + 3x^2/8$ ...

Subtracting (2.4) from (2.3) gives, to a first order approximation : $2\Delta v = (G\,M\,)^{1/2}\; r\; R^{-3/2}$ (2.5)

Thus, the Moon will spin with an angular velocity of $\omega_{\mathrm{m}} = \Delta v\,/\,r = (2)^{-1}\;(G\,M\,)^{1/2}\; R^{-3/2}$ (2.6)

in the same direction (sense) of what is observed in reality.

Since the Moon's orbit has an angular velocity of $\omega_o = v\,/\,R = (G\,M\,)^{1/2}\; R^{-3/2}$, (2.7)

it is proven that (2.6) equals half (2.7) ! And these values are independent from the radius r .

$$\omega_{\mathrm{m}} = \tfrac{1}{2}\,\omega_o \qquad (2.8)$$

This proves to the first order only that the “divergence spin” induces that the moon is spinning only half the expected value. Do the higher orders of the equation play a role? We will see this in next chapter.

Some people could think that the fact that “tidal forces” make the Moon rotating is due to a kind of polarity effect in the gravitation laws of Newton. This is wrong. Newtonian gravitation always can be reduced to the gravitational centre of the object. The fact that a spin occurs is only due to the fact that the radius of the Moon is not zero and that the gravitation field of the Earth is diverging.

Let me explain this differently : imagine a Moon whereof the mass is concentrated to its very small centre (99% made of lead or uranium or so), but it consists, for the remaining 1% of the mass, of very light but strong polystyrene that is tightly fixed to the Moons heavy core. The total radius of the Moon remains the same.
In that case, the Moon would rotate exactly the same way than the one we have calculated higher (to the first order). The equations can be applied exactly the same way. The reason is that there is no dipole effect at all, but that there just acts a divergence spin upon the extremities of the Moon.
This spin is only created by the fact that $a = v^2\,/\,R$ is only a geometrical relationship between a rotating object at a certain velocity and the perpendicular force that is needed to get that motion.
For the side of the Moon close to the Earth, the equation is not correct any more : a is larger due to its proximity and R is smaller. Both changes however do not restore the geometrical equation, though. So, v at that place has to change, what results in a final spin.
The same reasoning is valid for the side away from the Earth.

3. Do the higher orders of the gravitational divergence affect the Moon's spin?

This question is of utmost importance : doesn't the higher orders of the equations (2.3) and (2.4) affect the rotational motion of the Moon? Yes, they do! And here, we will see to what extend.

When we said, in the sentence between the equations (2.2) and (2.3) “We suppose that Δv and the radius r are more or less equal in both cases, which is correct to the first order.” we have to correct this in the first place. In reality, the side close to the Earth would 'weight' more than the side away from the Earth. This means that the gravitational centre of the Moon doesn't comply exactly with the Moon's core (or geometrical centre). So, the spin exerted upon the side close to the Earth will act on a shorter radius, say r-Δr and the spin exerted upon the side away from the Earth will act on a longer radius, say r+Δr . But the gravitational force upon the side close to the Earth is larger and the gravitational force upon the side away from the Earth is smaller.
When we re-calculate equation (2.5) including the higher orders, by replacing r

in (2.1) $(v+\Delta v\,)^2 = G\,M\,/\,(R–(r\text{-}\Delta r))$ (3.1) and in (2.2) $(v–\Delta v)^2 = G\,M / (R+r+\Delta r)$ (3.2)

we get respectivily $v+\Delta v = (G\,M)^{1/2}\;R^{-1/2}\;(1 + (r\text{-}\Delta r) / 2R + 3(r\text{-}\Delta r)^2/8R^2 + ...)$ (3.3)

and $v–\Delta v = (G\,M)^{1/2}\;R^{-1/2}\;(1 – (r+\Delta r) / 2R + 3(r+\Delta r)^2/8R^2 – ...)$ (3.4)

The average Δv can be found by subtracting (3.4) from (3.3).

In the first order, this changes nothing to our former result, in the second order, we get :

$$\Delta^2 v = –\;(G\,M)^{1/2}\;R^{-1/2}\,.\,3\,(2\,\Delta r)^2/8R^2 = –\;3/4\;(G\,M)^{1/2}\;R^{-5/2}\;(\Delta r)^2 \quad (3.5)$$

Hence, the extra change of spin of the Moon is given by :

$$\Delta\omega_{\rm m} = \Delta^2 v / r = –\;3\,(8\,r)^{-1}\;(G\,M)^{1/2}\;R^{-5/2}\;(\Delta r)^2$$
$$= –\;[\,3\,.\,4^{-1}\,(\Delta r)^2\,(r\,R)^{-1}\,]\;(2)^{-1}\;(G\,M)^{1/2}\;R^{-3/2} \quad (3.6)$$

which is depending from the size of r and that of Δr . The value of $\Delta\omega_{\rm m}$ is very small compared with (2.6) , but not totally negligible at all on the long term.
The value of Δr can be calculated by finding the gravitational centre of the Moon in the non-constant but linear gravitational field between the Earth and the Moon. This gravitational centre can be found by the integration of an infinitesimal part of the Moon over a part of the Moon's sphere. The balance between the part of the Moon close to the Earth and the part of the Moon away from the Earth, while putting the value Δr as the unknown solution of this balance, will give the solution for Δr .
In my opinion, this calculation is not worth to be done, because another influence, that of the Sun, might be more interesting to be checked. Besides, the clue of my paper will take in consideration a very different origin of the Moon-Earth locking system than generally expected.

4. What is the gravitational divergence influence of the Sun upon the Moon?

Let v_E be the orbital velocity of the Earth about the Sun, which is the average of the orbital velocity of the Moon about the Sun. Further, let us call $\Delta v_☼$ the change of velocity due to the Sun's divergence force at the level of r , which is the radius of the Moon. Let us define the orbital radius of the Earth as $R_☼$, which is the same as the average orbital radius of the Moon in relationship to the Sun. $M_☼$ is the Sun's mass.

For the side of the Moon that is the closest to the Sun, the change of velocity is given by the equation :

$$(v_E+\Delta v_☼)^2 = G\,M_☼ / (R_☼–r) \quad (4.1)$$

And for the opposite side of the Moon, the one that is the farthest from the Sun, the change of velocity is given by the equation : $(v_E\text{-}\Delta v_☼)^2 = G\,M_☼ / (R_☼+r)$ (4.2)

We suppose that $\Delta v_☼$ and the radius r are more or less equal in both cases, which is only correct to the first order.

$V_E + \Delta v_☼ = (G\,M_☼ / (R_☼\text{-}r))^{1/2}$, which is close to $v_E+\Delta v_☼ = (G\,M_☼)^{1/2}\;R_☼^{-1/2}\;(1 + r / 2R_☼ + 3r^2/8R_☼^2 + ...)$ (4.3)

and

$v_E – \Delta v_☼ = (G\,M_☼ / (R_☼+r))^{1/2}$, which is close to $v_E – \Delta v_☼ = (G\,M_☼)^{1/2}\;R_☼^{-1/2}\;(1 – r / 2R + 3r^2/8R_☼^2 – ...)$ (4.4)

Subtracting (3.4) from (3.3) gives : $2\Delta v_☼ = (G\,M_☼)^{1/2}\;r\;R_☼^{-3/2}$ (4.5)

Thus, the Moon will spin with an angular velocity of $\omega_{\rm m☼} = \Delta v / r = (2)^{-1}\,(G\,M_☼)^{1/2}\;R_☼^{-3/2}$ (4.6) in the same direction (sense) of what is observed in reality.

When comparing (3.6) with (2.6) let us express $M_☼$ and $R_☼$ in multiples of M and R .

Mass of the Sun : 1989100 . 10^{24} kg	Orbit radius Sun-Earth : 149,60 . 10^6 km
Mass of the Earth : 5,9736 . 10^{24} kg	Orbit radius Earth-Moon : 0,3844 . 10^6 km
Mass ratio (Sun/Earth) : 333000	Orbit ratio (Moon/Earth) : 389,18

Since the Moon's orbit has an average angular velocity about the Sun of

$$\omega_☼ = v_E / R_☼ = (2)^{-1} (G M_☼)^{1/2} R_☼^{-3/2} \qquad (4.7)$$

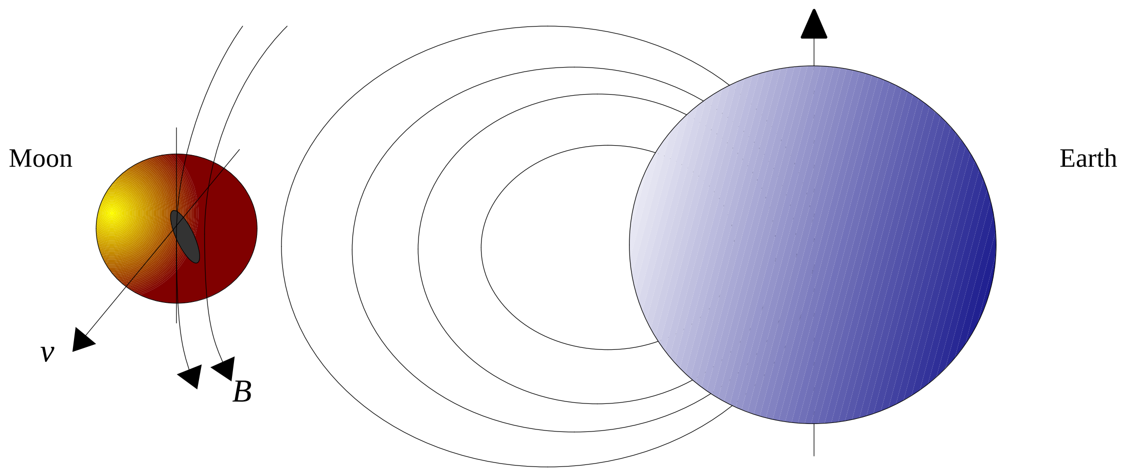
or $\omega_☼ = v_E / R_☼ = (2)^{-1} (333000\, G M)^{1/2} (389{,}18\, R)^{-3/2} = 0{,}075 . (2)^{-1} (G M)^{1/2} R^{-3/2}$

it is clear that the Sun influences the spin of the Moon as well : the Moon always should continue spinning about 7,5% faster than half its orbit period about the earth. This means that the Moon would then not face the Earth with the same side continuously. What went wrong in our reasoning ? Nothing went wrong. We indeed observe that the Moon tends to get over the limits of the side that is facing us and the Moon indeed shows periodically more of only half of its surface, but then suddenly, the Moon comes back in its former position again. What makes the Moon coming back to its original position, after having tried to go beyond its boundaries, due to the Solar action that makes the Moon spinning ? The clue of it is in the next chapter.

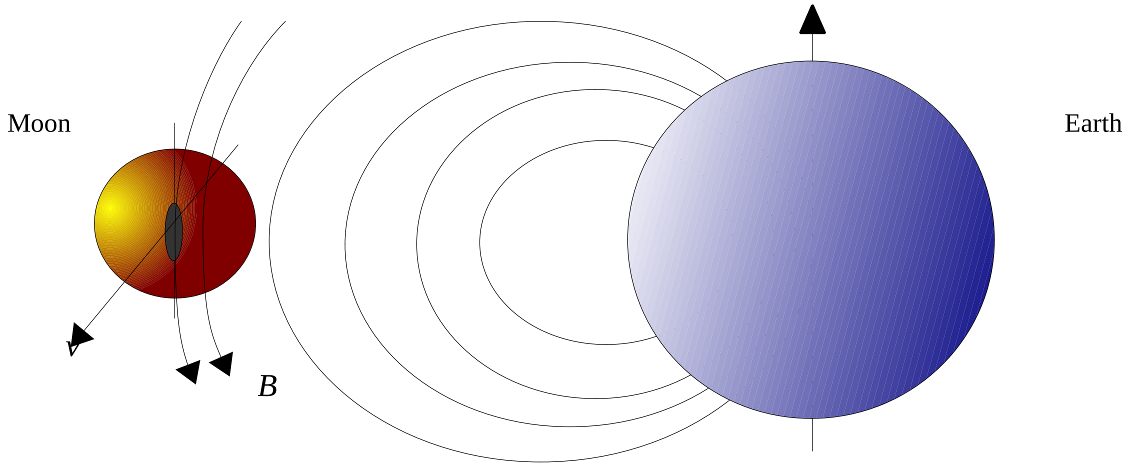
Reminder (I insist !) : the pure Newtonian gravitation always can be reduced to the gravitational centre of the objects of their system, and also here, the results have nothing to do with a polarity of any gravitational dipole whatsoever, even if the Moon would show a bulge. A bulge would only change the value of $(\Delta r)^2$ instantly in equation (3.6) , but that changes the rate of spinning, nothing else!
There is only a geometrical effect combined with the non-constant gravitational field that makes the Moon spinning.

4. The diverging magnetic influence of the Earth upon the Moon.

Imagine that the Moon's mass isn't perfectly spherically symmetric. This is very probable. Thus, the Moon has a mass that shows a non-spherical density. Moreover, the Moon is containing lots of iron, and that iron is sensitive to the Earth's magnetic fields.

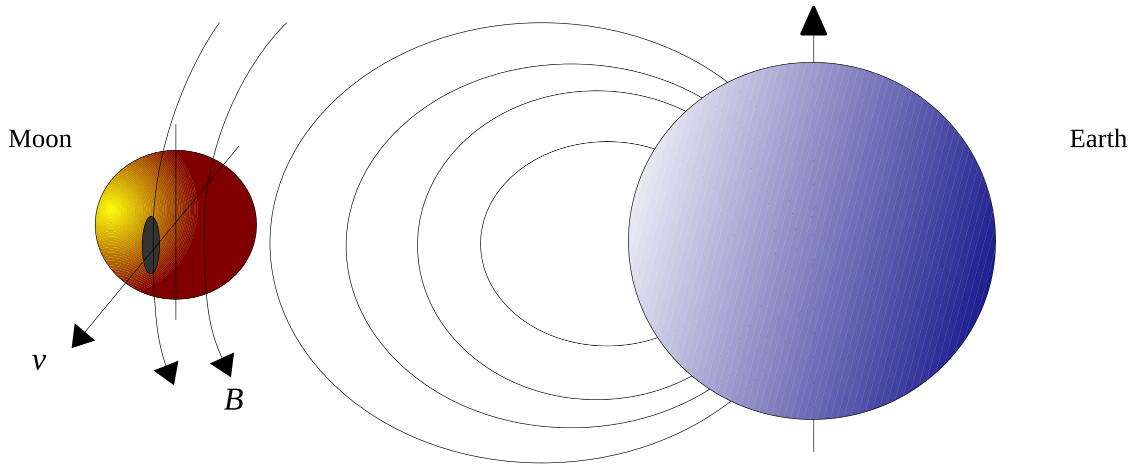


The drawn lines outside the Earth are the magnetic fields B that work onto the Moon's asymmetric iron content. The magnetic lines of the Earth, which are only acting upon iron and upon other magnetic-sensitive matter of the Moon, will generate the effect that the iron asymmetry will tend to rotate the Moon until the asymmetry is in line with the magnetic field. This is occasioned by a momentum that becomes zero when the alignment has been reached.



The question if the Moon will be able to reach that position will mainly depend of the sum of all the forces that are working upon the Moon. But is clear that the magnetic influence of the Earth upon the Moon is perpendicular upon de possible forces that would make the Moon facing us with always the same side.

Even when the asymmetric iron is not axial-symmetric but also eccentric, there is absolutely no force but only a momentum that is perpendicular to the axis Earth-Moon. Once the iron is lined with the magnetic lines, the momentum becomes zero.



Since the Moon can be considered as an electrically neutral object, without any electrical net charge, no other electromagnetic effect can be expected.

But there is another physical phenomenon. We know that the Earth's magnetic field is stronger at the side of the Moon that is close to the Earth, and is weaker at the side of the Moon that is away from the Earth. Let us make the following experiment: put some water in a cup, put a small piece of plastic foil upon the water and put a needle laying on it. It will tend to get lined with the North Pole along a magnetic line. We just fabricated a compass. Put now a strong magnet at each side of the cup, at the water level, but eccentrically in relation to the cup's diameter. The needle will not only be lined up with the two magnets, but the foil will move in order to get better lined between the magnets as well.
This is exactly what will happen with the Moon: the eccentrically iron will tend to move to the strongest magnetic field, the closest possible to the Earth. Thus, there is a preferential position of the Moon, that will be strong enough to maintain the same face towards the Earth, spites the influence of the Sun, and spites the second order influence of the Earth.

But, at the same time, the gravitational centre of the moon will remain the reference point for its orbital motion and its spin. This gravitational centre must be seen as the fixed rotation axis due to its orbital and its spin momentum, so that the Moon will change its position about this centre until the final state is found : the iron excess that finally points towards the Earth for ever.

5. Discussion and conclusion.

We can conclude that the divergence spin from the Earth on the Moon is such, that the same side is always facing the Earth. The Sun will tend to make the Moon spinning a little faster than half the Moon's orbit velocity, but the asymmetric iron distribution in the Moon retains this by keeping the excess of iron as much as possible faced to the Earth.
When the Moon orbits between the Sun and the Earth (new Moon phase) , the Sun exerts a stronger divergence spin upon the Moon than during the time that there is a full Moon phase. This creates oscillations about the mean spin velocity of the Moon within each orbital period about the Earth and it makes us seeing about 60% of the Moon in total instead of the expected 50%.

6. References and bibliography.

1. De Mees, T., 2005, Are Venus' and Uranus' Tilt of Natural Origin? , *The General Science Journal.*

2. De Mees, T., 2006, The Titius-Bode Law Shows a Modified Proto-Gas-Planets' Sequence, *The General Science Journal.*

3. De Mees, T., 2007, On the Tides' paradox , *The General Science Journal.*