Origin of the Moon

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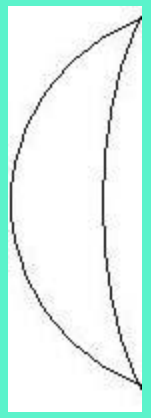
1. Inclination of Earth's axis of rotation
2. Origin of the Moon
3. Early Moon recession from Earth



1 Inclination of Earth axis of rotation

Billions years ago Earth rotation period was less than 24 hours, rather about three hours:

Based on the conservation of angular momentum principle, when we add the Moon with its orbit angular momentum to the rotating Earth, we get about 177 minutes rotation time, that is about 3 hours (BEFORE Moon was formed).

(3 hours also if adding the planets to the Sun)

$\dot{n}$

Deceleration of rotation

Earth is a giant gyro or top. Top equations are

$$\dot{C}n = M_1 \qquad (1)$$

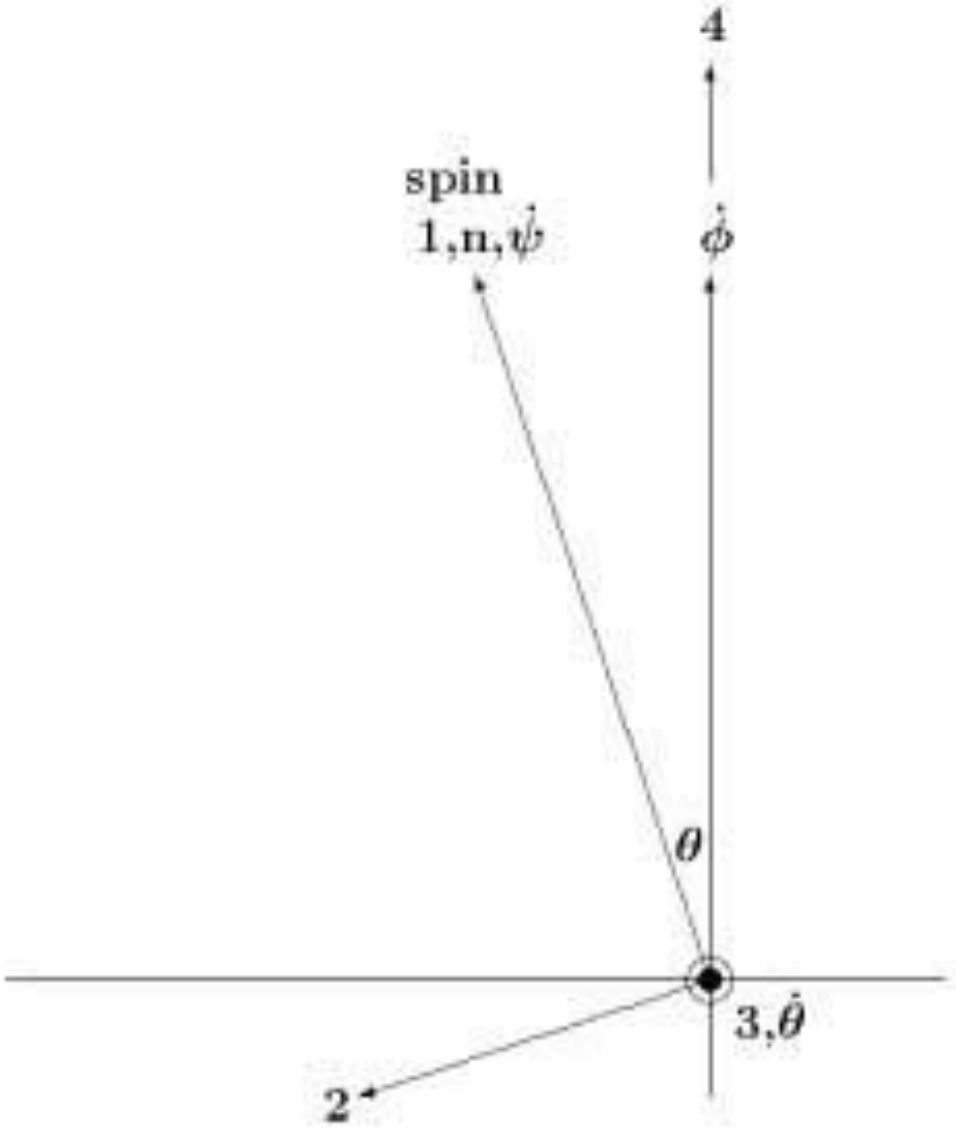
$$-A\ddot{\varnothing}\sin\theta - 2A\dot{\varnothing}\dot{\theta}\cos\theta + Cn\dot{\theta} = M_2 \qquad (2)$$

$$A\ddot{\theta} - A\dot{\varnothing}^2\sin\theta\cos\theta + Cn\dot{\varnothing}\sin\theta = M_3 \qquad (3)$$

where n is the absolute spin angular velocity:

$$n = \dot{\psi} + \dot{\varnothing}\cos\theta \qquad (4)$$

“Gyrodynamics” Arnold & Maunder



When

$M_1 = 0$ (5)

$M_2 = 0$ (6)

$M_3 = \pm K \sin\theta$ *(7)*

it is the well known Lagrange-Poisson case with closed analytical solution for fast rotation *n* and fast and slow precessions. *K* represents the restoring (-) or diverging (+) torque (per radian).

The solution for slow precession is:

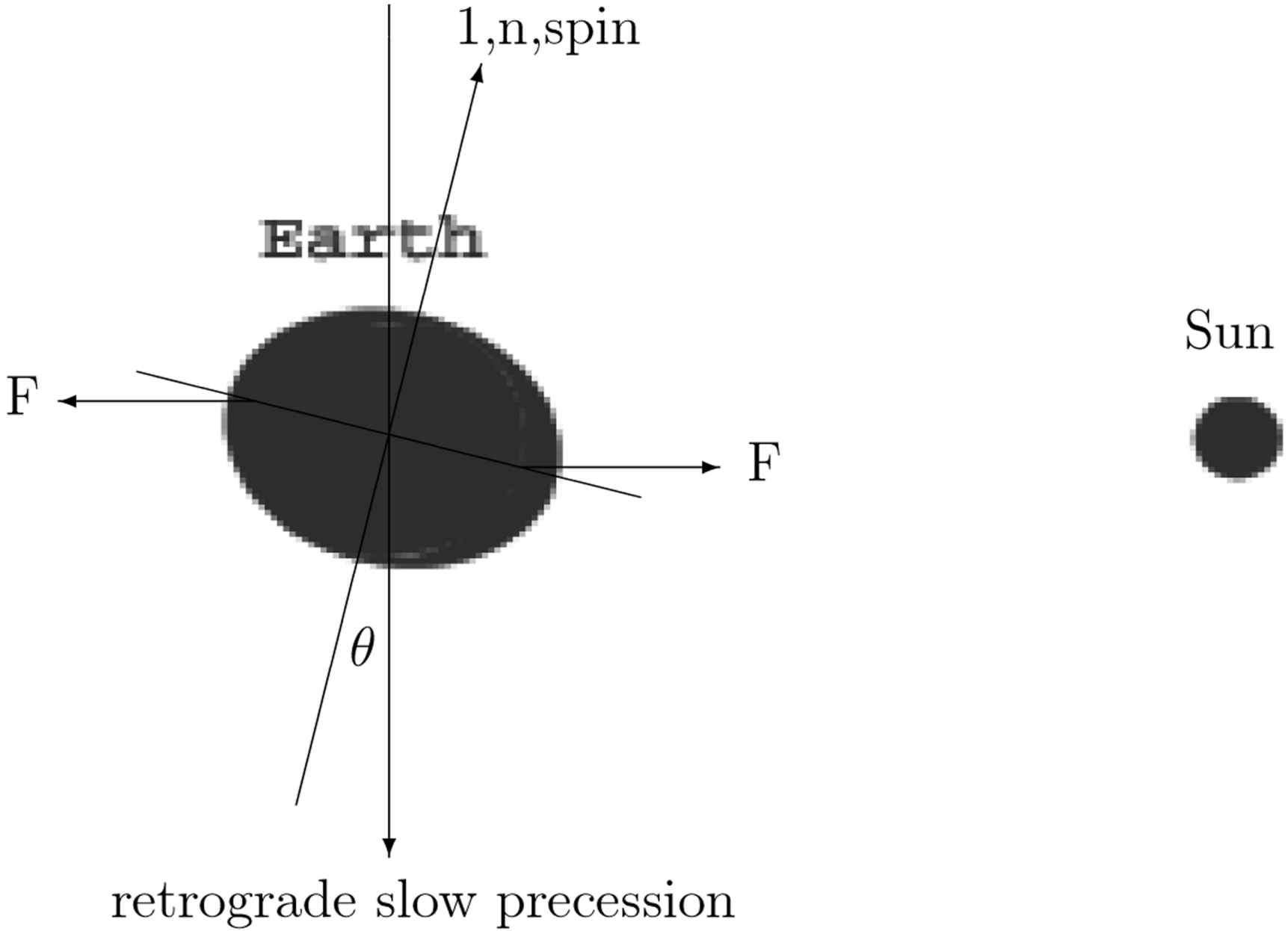
$$\dot{\phi} = \pm K / Cn \quad (8)$$

with fixed inclination angle:

θ = constant (9)

(plus small perturbations due to the second solution of fast precession), like in a usual top or gyro.

Torque that causes Earth precession



But what happens when M_1 and/or M_2 are not zero?

Using analytical iterations resulted in an approximated solution

(Ben-Amots, Acta Mechanica 1976):

.

The slow precession θ converges or diverges depending on M_1 and/or M_2

If the angular velocity n is constant, then M_1=0, and for the slow precession:

.

$$\theta = M_2 / Cn \qquad (10)$$

But we know that Earth rotation slowed down significantly from a 3 hours period to 24 hours period today.

That is, negative, braking M_1 torque originated in tides caused by the Moon.

For M_1 not zero,

$$\dot{\theta} = -M_1 \tan \theta / Cn \qquad (11)$$

or

$$\dot{\theta} = -M_4 \sin \theta / Cn \qquad (12)$$

Where $-M_4$ is the component of the breaking torque in the direction opposite to precession

SLOW DOWN CAUSES DIVERGING

So, while Earth rotation slowed down, its inclination angle *GRADUALLY* increased to the present 23.5 degrees.

We skipped some details, but the conclusion remains that no sudden impact by collision was needed to explain Earth axis inclination.

Furthermore, Venus's not yet explained retrograde slow rotation is the result of diverging the inclination angle up to 180 degrees.

So, how the Moon was formed without a collision?

2. ORIGIN OF THE MOON

George Darwin (1877, 1879, 1880) suggested that resonance separated the Moon from the Earth. (Others suggested that this left Earth with a scar – the Pacific). Later few scientists proved that such resonance could happen only while Earth rotated with 108 minutes period – a period that all believe is too short than could exist according to any theory. The suggested separation was then rejected in favor of a collision with another suggested planet (Thea)

But, there are many crucial difficulties with the collision theory.

- Rocks from the Moon were brought to Earth in Apollo missions about 40 years ago.
- Best scientists analyzed the elements and isotopes. Isotopes of tungsten and oxygen were found having so close percentage in lunar and Earth rocks, that it ruled out another planet, and also ruled out the expected complete meltdown of Earth during planets collision.
- But there are differences in volatile elements, posing difficulties for explanation without any melting either.

So, how did it happen?

My suggestion is - by *PEELING*. The area of the Pacific down to about 130 km was peeled from Earth, later to become a sphere known to us as the Moon.

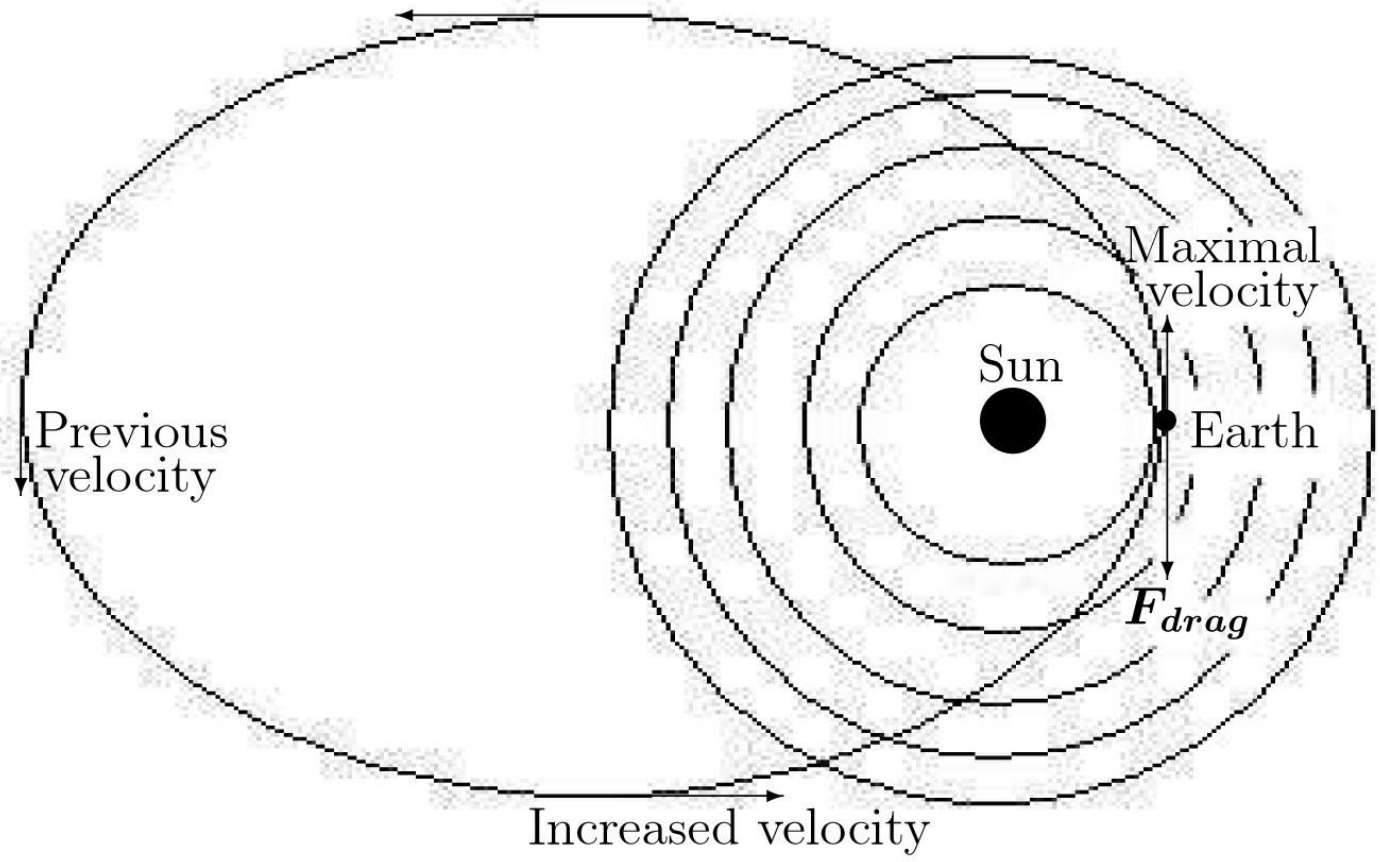
Such peeling needs *PARTIAL* melting at the Pacific, causing evaporation of volatile elements and compounds, especially water, but *NOT COMPLETE MELTDOWN OF THE EARTH*, which has not occurred according to geological findings on Earth.

But what could peel the Moon from Earth?

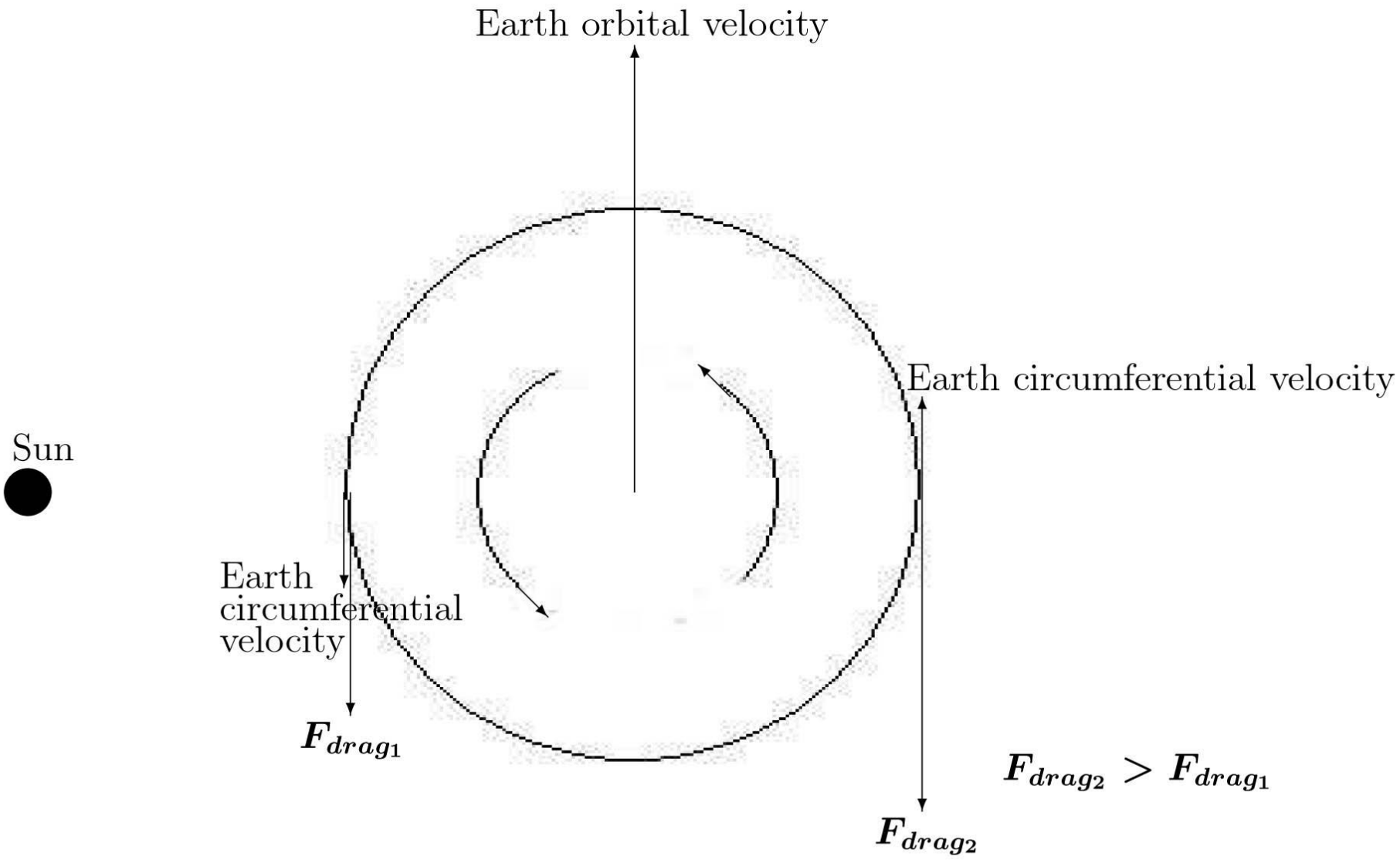
If Earth was disturbed and decelerated in its near circular orbit, and came inward toward the Sun in an elliptical orbit, then in these closer distances its velocity significantly increased according to Kepler's laws, and in these close distances Earth encountered the ambient thick gas of the primordial accretion disk close to the Sun.

This ambient thick gas caused friction and drag forces that we calculated could not lift the Moon from Earth, *BUT WERE SUFFICIENT TO PEEL IT ASIDE, AND ALSO WERE STRONGER THAN THE SHEAR STRESS OF ANY ROCK ON* Earth, not to mention significant softening up to *partial melting* by the friction heat.

Earth traveling in its new elliptical orbit enters the primordial thick accretion disk around the Sun



The ambient gas of the primordial accretion disk exerts different drag forces on the two halves/sides of Earth



- The larger drag force on one side of Earth crust peeled part of it in this side.
- The hot peeled part (The Pacific as suggested after George Darwin) became later the Moon. The material came from the Earth only (not from another planet). Yet the high temperature evaporated water and volatiles, but without complete meltdown of Earth surface.

3. Early Moon-Earth recession

Williams (1990, 1997) calculated from sediments measurements the length of day and Moon recession rate during last 2.5 Billion years, enabling us to calculate the distance Moon-Earth 2.5 BYA (Billion Years Ago) as 37500 km closer than the present average distance nowadays of 385000 km, that is 347500 km distance, and the recession rate 2.5BYA was found as 1.27 cm/year.

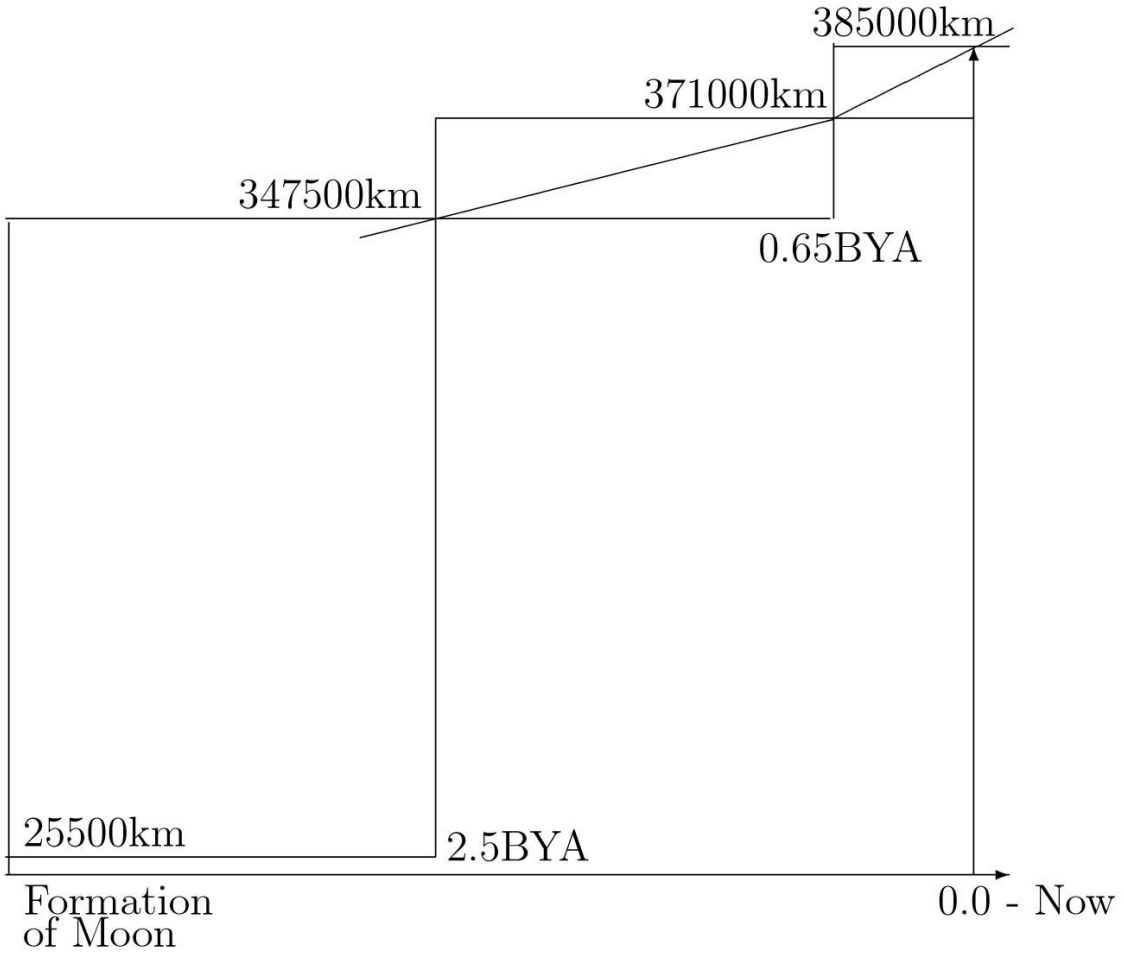
Also, Moon could not form closer to Earth than Roche radius 18420 km (Roche 1848, 1851).

Ida et al. (1997) claimed that the Moon was formed at distance of 2.9-4.6 Earth radii (18500 – 29350km).

We used 4 Earth radii ≈ 25500 km.

FURTHER ESTIMATIONS

We use Wiliiams's and Ida et al.'s findings/claims as *BOUNDARY CONDITIONS*.



FURTHER ESTIMATIONS

Approximating further by assuming an *exponential recession function*, and the time when Moon's ocean tides started to slow Earth rotation as 4.45 BYA, we calculated (without simulations) and found the following "not impossible results"

For the proposed exponent function that we assumed, the equation for the recession velocity is

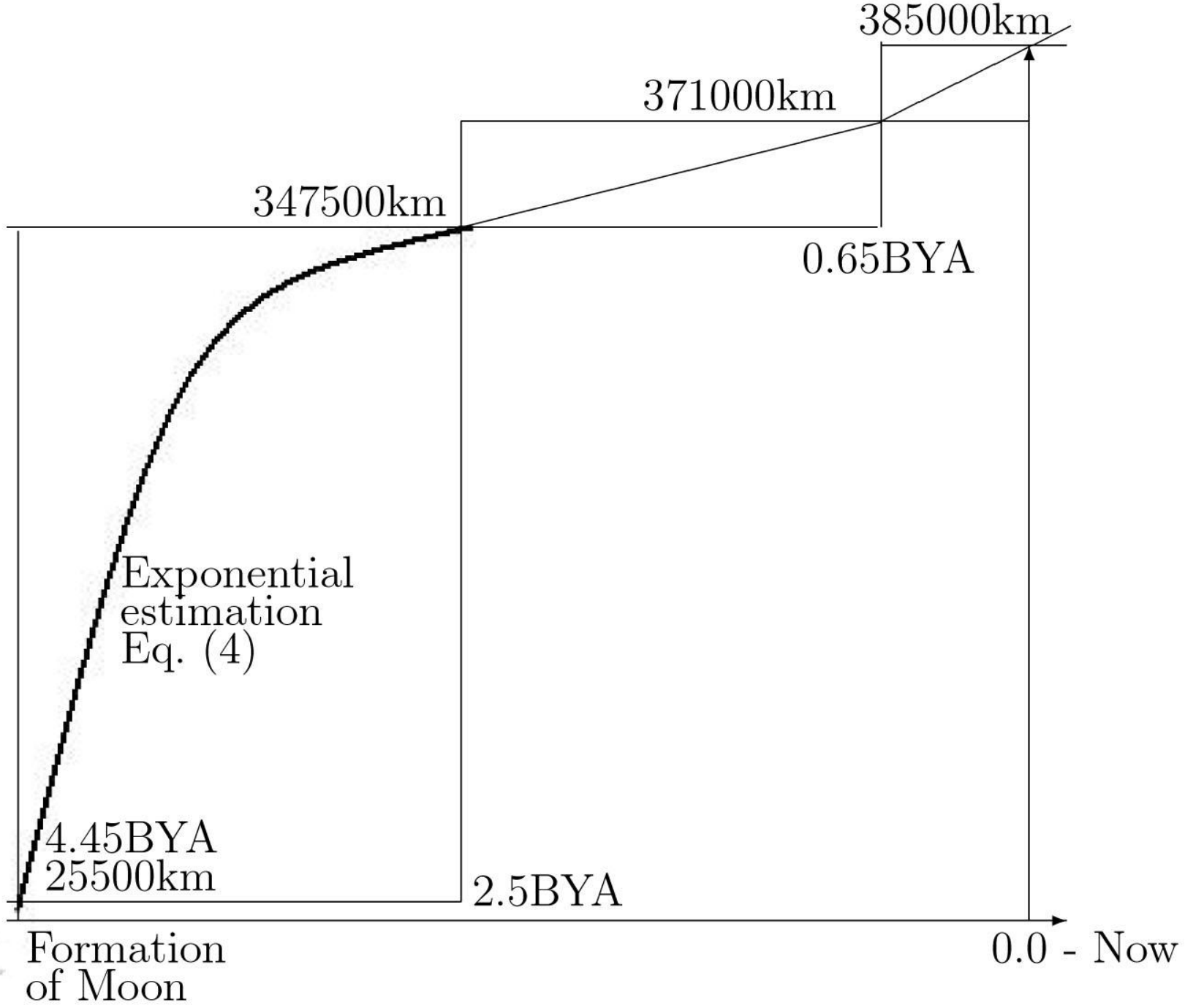
$$v = b \times \exp(-a \times Time) \quad (13)$$

The distance of the Moon is the integral of the recession velocity:

$$x = \int (v dt) = -(b/a) \times \exp(-a \times Time) + Constant \quad (14)$$

Using the three boundary conditions, we got the values of *a*, *b* and *Constant*.

Substituting *a*, *b* and *Constant* in (13) and (14) we could calculate estimated *v*, *x* and other results for any time between 4.45-2.5 BYA.


385000km
371000km
347500km
0.65BYA
Exponential
estimation
Eq. (4)
4.45BYA
25500km
2.5BYA
Formation
of Moon
0.0 - Now

OUR NEW RESULTS:

Earth recession rate started maximal 66.7 cm/year.

During first 395 Million years of ocean tides, in near equatorial regions the tide velocity was *SUPERSONIC IN WATER*.

The minimum time between two lunar peaks was 128 minutes, that is more then 2 hours, about 20 million years after the beginning of ocean tides.

Earth minimal rotation periods was 177 minutes, BEFORE THE MOON WAS FORMED, (=almost 3 hours, which is still more than the 108 minutes needed for George Darwin's resonance).

We calculated tables with new intermediate estimated values for distances, recession rates, energy, power and more, during about 2 billion years BEFORE 2.5 BYA.

Other assumptions will lead to somewhat different QUANTITATIVE results, but not different QUALITATIVELY.

CONCLUSIONS

Earth inclination angle evolved gradually.

Venus retrograde rotation is a similar gradual evolvement, but up to 180 degrees.

Moon originated in *PEELING* from the Pacific.

This explains Apollo rocks isotope measurements.

Moon-Earth distances, Moon recession rates, energy, power, minimum time between tides peaks, supersonic in water tide velocity and more were estimated during the 2 billion years before 2.5 BYA.

Important references

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