Earth´s Moon

in sight but overlooked

report

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1 introducing facts

Everyone knows, that earth´s moon orbits the earth about once a month and influences us causing tides. Beside this fact it is clear, that moon´s trajectory has a big angle compared to the equator of the earth, otherwise he wouldn´t change his position on the firmament a bit every earth night. Apperantly nobody expects, that our familiar moon is somhow extraordinary!
Understanding why, we should first get preciser informations about the physical properties of the moon.[3] Lets start with the time of circulation, which is 27 days, 7 hours and 44 minutes, rotating in the same direction as the earth orbits around the sun. Its inclination to earth´s equator is variing between 28.6 and 18.3 degrees, due to the precession of earth. The inclination to the ecliptic is roughly 5 degrees. Furthermore, the average radius of the circlelike rotation of the moon is about 60 earth radia. Precisely you can estimate, that the excentricity is about 0.055, meaning the difference between the nearest and farest distance to earth is about 5.5 percent of the average radius. The mass ratio compared to earth is about 1.23 per cent, and the density ratio is 61.5 percent.

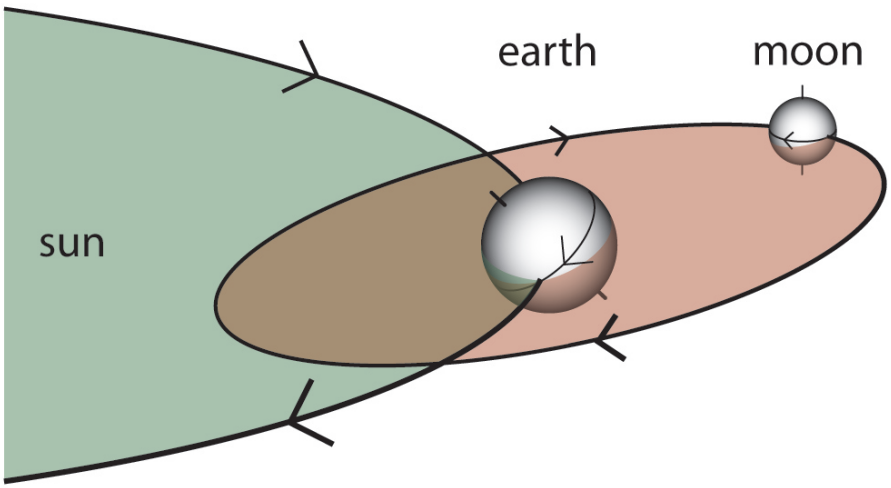

Figure 1: Trajectory[9]

A often forgotten fact is, that the moon is facing only one side towards earth. Actually he rotates around his axis with the same time as he orbits around the earth with an small average axial tilt of 5.2 per cent. Interesstingly we explored the hidden side of the moon first in 1959 with a spacecraft.

2 structure

Beyond the physical values, i will introduce to the structural specialties of the moon, advancing from the center of the moon outwards. The moon has like the earth a core consisting of metal, but it´s only 1-3 percent of the whole mass of the moon, explored by magnetic fiel measurements. Earth´s core is unlike about 20 percent. About 800 km away from the center is a boundary layer detected by seismometers, observing many centers of moonquakes in this region. There is the transition from fluid to solid state. Beyond this 100km thick transitionlayer begins the mantle of the moon with a thickness of about 900 km, surrounded by a 70 - 150 km thick crust.

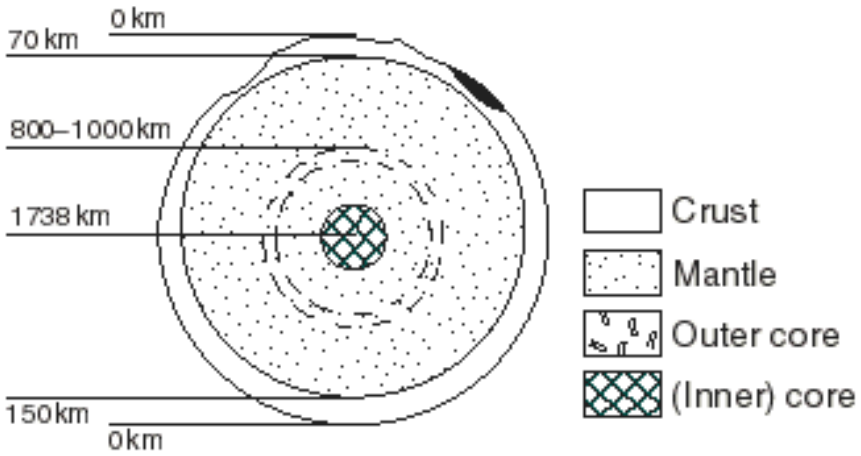

Figure 2: internal structure[10]

From some pieces of moon stone, we know, that the moon has an identical oxigen isotop configuration as the earth, estimated by laser-fluorination in 1990. The birth of moon was about 50 million years ago, measured by Hafnium-tungsten-dating from moon stones[1]. Neglecting the low metal and water concentration, the moon is more or less built up of the same substances as the earth. Besides that the concentration of Aluminium, Kalzium, Thorium and Uran, all fast precipitating elements, is slightly higher than on earth.
Furthermore, the moon has also a very thin atmosphere built up of Helium, Neon, Hydrogen and Argon with roughly 20 percent concentration respectively. The pressure is however so low, that you can hardly call it atmosphere. Besides this the moon seems to have had an own magnetic field, but it decreased to very low values.

3 formation theories

Comparing the datas of our moon with other moons in our solar system, you see many anomalities. Normal moons have a small angle to the central medium´s equator. Besides this the moons have also a mass ratio of less than 10^{-4}compared with the central medium. Another fact is, that the havier moons normally orbit at distances less than 20 radia of the central medium. All these facts indicate, that our moon originates differently. In the following, i want to present some theories, how our moon was generated[6][5]. Most of them are not up to date anymore, but none the less showing the imagination of mankind in the past.

3.1 capturing theory

A simple explanation is, that the moon was captured by the earth, due to its gravitational field. This theory is very weak, because normally a object which is attracted from infinity will pass the earth and will afterwards disapear in infinity. It has to loss some energy while passing the earth, to privot in an elliptic orbit. This is very unlikely, because the moon should have had a very descret trajectory. There is only one moon called Triton, where we assume, that he was chaptured by Neptune. But this caused other moons to leave Neptune, so Triton could loose energy. Besides that we know, that the moon has the same oxigen signature compared to the earth, which indicates, that it was built in the same region of the solar system as the earth.

3.2 spliting theory

Another explanation is, that the moon was dropping of the young fluid earth, because of a very fast rotational speed of the earth. This would explain the same oxigen signature. But this would require a very high angular momentum. The angular momentum at the moment is only 25 percent of that which you would need for this theory. It´s hard to explain, where the other 75 percent have gone even if you take into account, that some was lost in the dissipative forces of tides. Moreover the fast precipitating elements concentration should be absolutely the same, like on earth. Water is neglected because it´s not really understood, where the water on earth came from.

3.3 double planet system

The third theory assumes, that earth and moon developed simultaneously as a double planet system, like Pluto and Charon. Guessing this, the chemical

concentrations of both planets should be roughly the same. But the moon has only a very little amount of iron in the core, which calls this theory into question. Even the double planet system of Pluto and Charon we guess, has developed from the capturing of Triton by Neptune, where Pluto and Charon where first moons. So a double star system is very unlikely in our solar system.

3.4 impact theory

The most applicable theory at the moment is an impact of another planet with the earth, whereby the moon was built. This object should have had 10 percent of the mass of the early earth. The collision accured under a small angle in a time, where the earth was already building out its first crust. This was knocking out only crust material, because the heavy metal was already forming a core in the inner earth. The knocked out material was orbiting around the earth and slowly formed the moon. Looking closer to this theory, you recognize that it explains both the light core of the moon and the identical oxigen signature. The big problem is to simulate this event correctly. Normally you will expect, that a knocked out particle falls back to earth or disappear in infinity. So there have to be recognized many different forces(pressure and gravitational forces between the particles) between a huge amount of particles for simulating it.

Figure 3: impact simulation[11]

Simulations have shown, that there is formed a dust cloud around earth. This cloud is mainly within the Roche-limit of the earth(1.5-3 earth radia), where every bigger object is ruptured due to earth´s gravitational force. But this clouds spit out some fractions of mass over the Roche limit every now and then[2]. This mass grows on and attracts then some mass of the dust cloud, when it is big enough. Finally it is possible to form a bigger moon out of this impact, which only takes about two weeks[1].
Even if it is very difficult to simulate this event, it is none the less the most consistant and simplest theory of formation of earth´s moon at the moment.

4 the bright and the dark side

As i mentioned at the beginning, the moon rotates around his axis with the same angular velocity as he orbits around the earth, hence showing us only one side of himself. This seems firstly to be an unlikely coinsidence, but if you analyse other moons, you can observe the same behavior for many moons, like the moons of mars or the system Pluto and Cheron. There has to be a physical reason for this tidally locking to the central medium occuring so often in the solar system.

4.1 tidal locking

Assuming you have a moon rotating around a central mass with a faster rotation around the axis than the orbital angular velocity. Gravitational forces will stretch both bodies a little towards each other. But the moon rotates faster and turns this bulge away from the central mass. This causes a force which tries to pull it back to the connection line between the two bodies. The stable state is that the bulge is a little bit in front of the connection line. But there is also a little dissipative force which slows the moon down continually until it is tidally locked to the central body.
This occurs not only to moons, we are noticing this force caused by our moon also on earth, which causes high and low tide. This force also slows down earth´s angular velocity.
If you now look closely at the surface of the moon you can actually observe about 59 percent of the surface, which has a couple of reasons summarised in the noun libration.

4.2 librations

First reason for seeing more parts of the moon is the excentric trajectory. Hence the moon has different velocities at the apogee and perigree. So he is one time moving to fast and one time to slow in comparison to the axis rotation. Thats why you see more parts in longitude.
Another fact is that moon´s equator has a little angle to his trajetory´s plane. Due to this you can see a little bit more of the south and northpole of the moon. The last reason for observing more is the fact that we on earth move about 12,000 km, while we can see the moon. So we are passing the moon.

5 future prospects

At the moment, scientist are seeking after the presence of water on the moon, which is nessecary for future plans for permanent settlements there. It would be used to block the cosmic radation, which is not shielded by a magnetic field like on earth.[4]
Another attempt is to scan the whole surface for the composition of different elements with spectrometers. Besides this we also want to know more about the interior of the moon. Most information we have are from seismometers. This would reveal more about the history of the moon and the correctness of the impact theory.
Finally there are some geological formations on moon called grooves, whoss origin is not really understood. Another interesting area are the craters, which show up some gravitational anomalies called mascons.
The interest in moon missions is raising again all over the world. Nasa wants to start again some moon missions, where astronauts will stay one week on the moon. The new spacecraft should be possible to land not only on the equator, but all over the moon. Some companies in europe want to build up a radio wave teleskop on the moon and want to extend it afterwards to a moon base. Furthermore there are more and more countries seeking for the space, like China, India and Brasil, which makes future moonbases(crewed or uncrewed) very propable.[4]

References

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