The Story of the Moon

It is not just the origin and formation of the Moon that is still an enigma, the future of the Earth’s Moon also holds several mysteries.

The Moon, Earth’s lone companion, is an enigmatic celestial object. There is so much mystery shrouding the birth of the Moon, we are still learning about its origins. Many theories regarding its formation have been formulated. While many remain hypothetical, a few stood ground for some time as they appeared logical at that time.

Missions to the Moon have significantly changed the perception over time. Rocks and samples collected from the surface during the Apollo missions have opened new insights. With advancements in technology, explorations and observations, many theories which were hitherto accepted as probable are being squashed. Thanks to better simulation methods of space conditions, now the theory of the formation of the Moon stands revised.

As astronomers began benefiting from better equipment and rapid advancements in discoveries, many theories were proposed for the formation of the Moon. Three prominent theories prevailed for a long time.

Capture Theory
This theory believed that the Moon was formed somewhere in the Milky Way and had its own trajectory. While travelling in its orbit it accidentally came into the Earth’s orbit which captured it; since then it has been revolving around the Earth as a satellite.

Supporting evidences: The Capture Theory, while sounding logical and probable, well explained the differences in densities between Earth and Moon. The difference in size from Earth, tidal locking and its own orbit also favour this theory.

Shortcomings: For the Moon to be captured, it is required that both (Earth and Moon) pass each other at slower

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speeds. Also, the Moon’s orbit would lose energy when it came close to that of the Earth resulting in either a collision or a change in trajectories. Moreover, if the Earth captured it then the gravitational pull of the Earth would be significantly altered and at some point in time it has to release the Moon too since the Earth would not have had sufficient energy to sustain the capture. All these factors go unexplained by this theory. It also failed to explain why the Moon’s surface contained similar oxygen isotopes as that of the Earth.

Despite the anomalies, this theory was taken into account till a few decades ago.

Co-formation Theory
Another theory that found acceptance was that both Earth and Moon were formed at the same time from the same nebula (space cloud) when the solar system was being formed and condensed to form the entities.

Supporting evidences: The age of the Moon is also close to that of the Earth – around 4.5 billion years, which holds this theory in good stead. The geochemical similarity is also justified as the base formation is from the same source.

Shortcomings: The theory lacks in explaining why the Moon does not have a similar core composition as that of the Earth. Moreover, if both were co-formed and condensing then the Earth’s gravity would have drawn it to fuse with it rather than developing it into a satellite. The angular momentum of the Earth-Moon system also could not be explained by this theory.

Fission Theory
The next theory that was suggested in the 1800s was by George Darwin (son of Charles Darwin, the famous naturalist). According to his theory, the Moon was formed from the primitive Earth when it was in a stage of high spinning molten mass. During this time, a huge internal fission must have ejected a fragment of itself. This piece flung outward, was
caught in the gravitational pull of the Earth and began rotating around it.

Supporting evidences: Strengthening this theory, an Austrian geologist Otto Ampherer in 1925 theorised that the formation of the Moon was the chief cause of the continental drift; the mined chunk which came off the Earth’s surface could have originated from the Pacific Ocean, he summarised, as he analysed the huge crater found in the ocean.

A 2010 study conducted suggests that concentrated radioactive elements may have provided the kick-start to the apparent fission theory which could have led to the Moon-piece to be dislodged in the early life of the Earth.

Shortcomings: Most scientists discount this theory as they estimate that the Earth could not have been spinning so fast as to eject a piece of itself. This theory also fails to explain the angular momentum of the Earth-Moon system. Technological advancements later debunked this theory. It was found that the Pacific Ocean crater was formed some 2 billion years ago and hence could not be the source of the birth of the Moon which is around 4 billion years old. Moreover, when Apollo missions brought back Moon rocks, they differed in composition to that of the Pacific Ocean rocks.

Colliding Planetisimals Theory
Another hypothesis suggests that when planetisimals – tiny planet like objects – collided into each other to form the planets in the early solar system they created a huge amount of dust and space debris. This debris around the Earth region would have condensed to form the Moon.

Supporting evidences: This theory is by far the most widely accepted theory as it explains many concepts which were not understood clearly earlier. The low iron content of Moon’s core is explained as the Moon is said to be formed from surface mining. Since the major concentration of iron is in the Earth’s core, it can be understood why it is absent from the Moon’s core.

The geo-chemical similarity – the elemental and surface similarities of Moon and Earth – stand explained as Moon was formed from a part of the Earth. The presence of oxygen isotopes similar to Earth’s is also assessed to coincide. The angular momentum of the pair is well understood.

When Apollo missions brought back samples of Moon rocks, it was studied much more deeply and the theory was validated further.
Shortcomings: But despite many factors being explained, a few things still remained puzzling. While Theia collided and merged with Earth, the elemental traces should have been found in the Moon too. But the Moon samples do not indicate the presence of any impactor substances. However, the oxygen isotopes were similar to Earth which led to theorise that Theia and Earth melded together and then it was distributed in the Moon too.

The giant impact theory has been widely discussed and tweaked during the past few years. Despite the evidences scientists continue to find solutions to the puzzles the Moon poses.

**Recent Development**

A recent discovery made in January 2017 suggested an alteration in the giant impact theory. Squashing the single giant collision theory, this discovery made by researchers from Israel – Raluca Rufu, Oded Ahronson and Hagai B Perets – explains that it is not a single huge collision that is responsible for the Moon but several smaller collisions of space rocks that led to the formation of chunks of space debris, called Moonlets, in the Earth’s orbit.

The study indicates that our Earth in its formation stages was a mass of molten lava and rocks; a continuous rain of bombardments from space rocks led to a cloud of debris and dust around the Earth. The Earth was surrounded by a cloud of space rocks and debris formed by the rubble of molten and mined Earth surface. These over a period of time cooled, collided amongst them, naturally crossing paths in orbit and agglomerated to form Moonlets.

The tidal forces of the Earth further pushed the Moonlets into orbits and as they moved away in individual orbits, they coalesced to form bigger Moonlets. Finally after a series of coalitions, the present Moon was formed.

The Moon we observe in the sky is not the original Moon; but going by the latest theory is one of the last of a series of Moonlets that merged to form the present Moon. The scientists by conducting nearly 800 space simulations in the laboratory concluded that 20 Moonlets fused for billions of years to form the Moon. Their findings were published in the journal *Nature Geoscience*.

**Supporting evidences:** Concepts of physics too are justified as several smaller and high impact collisions actually gave rise to the surface of the Earth. With this theory the component similarity of Moon with Earth is well explained and so also the angular momentum of the Moonlets. Since the tidal forces of the Earth acting on Moonlets is significant, they naturally tend to move outward. This angular momentum gives rise to the Moonlets crashing together and forming larger chunks.

**Still Enigmatic**

But amidst all this, another interesting fact of the Moon is that it is gradually moving away from the Earth. Affected by the tidal forces of the Earth’s gravity, it is progressing outward at the pace of 3 cm per year; it may appear insignificant now but over the course of millions of years hence, is it possible that the Moon will become another planet by itself? Will further impacts from space debris be adding and hastening this transition?

Whatever changes may occur on the Moon, it is evident that there will be a direct impact of this on the Earth. Life on Earth will see major changes with the Moon moving further away. It is the tidal forces of the Moon that keep the oceanic bulge on Earth; it is also due to Moon that the Earth’s wobble in its orbit is smoothened.

Perhaps the coming millennia will see the Moon escaping away from us; or impacts from space objects may give rise to Earth having additional moons. All these open interesting questions about this mysterious heavenly object. The Moon is undergoing transformation continually and remains enigmatic to us.

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