# WHAT CAN ASTEROIDS AND COMETS TELL US ABOUT HOW THE SOLAR SYSTEM FORMED?

## Summary

Asteroids and comets confirm the prevailing theories on the formation of the solar system. Their composition and their respective location indicate the original features of the solar nebula cloud in the prevailing solar nebula theory on the origin of the solar system. Asteroids are rocky objects found in the region referred as the asteroid belt between the orbits of Jupiter and Mars, and their orbits intersect earth's and Mars’ orbits. Both comets and asteroids are in an angular momentum around the sun, though they have irregular orbits compared to the elliptical planets orbits. The motion of these objects points to the initial angular spinning of the solar nebula cloud of gas and dust following its collapse under its gravity. Since there is no torque to change the angular momentum, like the planets and the sun, asteroids and comets are in a similar angular motion like most of the solar system objects. The solar nebula theory postulates that the cloud of gas and dust collapsed and spun faster adopting a disc shape. This explains the planar positioning of asteroids, comets, and planets around the sun. The heat at the centre of the disk could not have allowed the formation of the Oort cloud close to the centre, explaining the present day location of icy comets further away from the centre of the solar system. The initial disk was hotter at the centre and cooler further, partitioned by a frost line. This implies that the composition and location of asteroids and comets reinforce the solar nebular theory of the formation of the solar system. Comets as icy, signifying the colder external disk while Asteroids are rocky objects implying the denser inner surface of the original nebula disk.

## Introduction

Apart from the sun, planets, and moons, the solar system includes numerous small objects which are classified as asteroids, comets or even interplanetary dust. As noted in Chapman and David (1975), there are over 2000 asteroids of varying size with Ceres being one of the largest at 1000 km in diameter. Asteroids have distinctive irregular shape and usually found in in the asteroid belt between Mars and Jupiter. Asteroids are classified based on their orbits and also according to their albedo and spectral reflectivity (Carr *et al.*, 1984). In accordance to their orbits, the Amor asteroids have their periphelia inside the orbit of Mars but outside the earth's orbit. The other class of asteroid based on their orbit is the Apollo asteroids that have their periphelia inside the earth's orbit and therefore have the potential of impacting both Earth and Mars. The composition of asteroids can be differentiated based on their reflexivity and their albedo.

Comets have been described as agglomerations of dust and ice which have been collected in orbits far beyond planetary orbits (Seargent, D., 2017). Comets occupy the Oort cloud in large numbers believed to be up to 1012. Comets orbits' are plunged in the inner solar from the Oort cloud due to the perturbations of their orbits by passing stars (Carr *et al*., 1984). Therefore, their orbits adapt a near parabolic shape around the sun where their visible and characteristic shape can be seen. Two types of comets can be distinguished, the periodic and non-periodic comets. The non-periodic comets constitute the largest population of comets where they occupy parabolic orbits and pass through the centre of the solar system once. Periodic comets have their orbits perturbed by planets, mainly Jupiter, leading to low inclination prograde orbits.

## Results and Discussion

Comets are icy planetary leftovers after the formation of the planets. They are characteristically indicating that the solar nebula was rich in ice. Whereas asteroids are rocky, their orbits intersect inner planets orbits showing they are remnants of a failed planet formation, mainly due to the presence of Jupiter. The different structure and composition of the planets, asteroids and the comets support the nebula cloud theory of the formation of the solar system from a gas cloud collapsing from the effect of its gravity. The collapsing nebula cloud theory is supported by the small rocky objects, asteroid, at the inner solar system and smaller, icy and rocky comets at the distance Kuiper belt and Oort cloud. Like the planets, comets and asteroids have an ordered motion around the sun, indicating the earlier spinning motion of the solar nebula gas cloud. Asteroids and comets serve as time capsules of the formation of the solar system. For instance, asteroids are believed to be the primordial material left after the formation of the planets because of Jupiter gravitational pull or through a collision of a planet.

The sequence of events in the nebular cloud theory formation of the solar system began with a gas cloud that started to collapse under its gravity. This was followed by increased spinning speed and heating up, reducing the vertical motions and creating a spinning disk. The collapse of the disk stopped when the cloud started spinning at orbital speed. The giant, swirling cloud of gas collapse is explained in two principles of physics. Firstly, the Newton’s Law of Gravity where gravitational potential energy is transformed into heat/thermal energy and the conservation of angular momentum where rotational motion is conserved. The momentum involved when an object is spinning is its angular momentum given by **M**ass x **V**elocity x **R**adius. In the absence of anything that causes a change in the angular momentum (torque), the total angular momentum remains constant (is conserved).

Angular momentum conservation:

Rotation speed ∝ 1/cloud diameter

As the cloud collapsed, energy was conserved:



Gravitational collapse gas shocks

The initial disk was hotter at the centre and cooler further, partitioned by a frost line. Within the frost line of the disk, rocks and metal clumped together to form the terrestrial planets while outside the disk frost line, there were icy planetesimals which were hugely massive, forming gaseous (Jovian) planets composed of mostly hydrogen and helium. The Oort cloud where comets originate from is believed to have originated from the outward gravitational scattering of the planetesimals by Uranus and Neptune (Perryman, 2011). The composition and the location of asteroids and comets seem to reinforce the solar nebular theory of the formation of the solar system. Comets as icy, signifying the colder external disk while Asteroids are rocky objects implying the denser inner surface of the original nebula disk (Woolfson, 2000). This model explains the pattern of the rocky terrestrial bodies closer to the sun with high volatile content and the icy object of the Kuiper belt.

## Conclusion

In conclusion, asteroids and comets serve as time capsules supporting the theories such as the solar nebula theory on the origin of the solar system. They adapt the same motion as by the planetary bodies and the sun indicating the original spinning motion of the original solar nebula cloud. As it collapsed under its gravity, it spanned faster and heated up towards its centre as the gravitational force was transformed into thermal energy. This explains the presence of the Oort cloud from which the icy comets emanate. Since there is no torque to change the angular motion, the sun and most of the planetary objects continue spinning in the same directions as the original cloud. The properties of individual planets explain the proximity of the planets to the hot proto-sun in the solar nebula theory on the formation of the solar system. The composition and location of asteroids and comets confirm the theory as debris left after the solar system formation. The sun was formed in the centre where the collapsing nebula had high temperatures and density to allow for nuclear fusion to occur. The planetesimals, asteroids, and comets, explain that all planets lie one plane and spin in one direction as most of their satellites (moons). The asteroid belt and the Oort cloud are located away from the inner solar system where the nebula disk was less hot.

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