

## Asteroid Belt Creation

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### Abstract

In solar system, asteroid belt is the ring shaped disc located between Mars and Jupiter consisting of irregular small bodies called asteroids. Almost half of the mass of the belt lies in four asteroids which are Ceres, Vesta, Pallas and Hygiea. Along with asteroid bodies, bands of dust with particle radii of about few hundred micrometers are also a part of asteroid belt. Total mass of asteroid belt is only 4% of the mass of Earth's moon. The author has studied the causes of asteroid belt in the solar system and has found out that how the gravitational interaction between the two planets is involved in the formation of asteroid belt and how the gravitationally bound system becomes stable enough to avoid any disturbance in the distances of its astronomical bodies.

**Keywords:** Asteroids; Barycenter; Solar system; Gravitational force; Expansion of universe; Vortices; Voids

### Introduction

In Universe, we see that two gravitationally interacting bodies revolve around their common barycenter. In case of our solar system, we observe planets revolving around the Sun because barycenter of the Sun and any planet lies inside the Sun. Similarly moons seem to revolve around their respective planets [1]. In many star systems, the two stars show their clear motion around their barycenter e.g. in binary star system. This means unlike barycenter in terms of physics (which is a common center of mass of two bodies which are connected either through rod or any other physical mean), barycenter in astronomy is the point of balance of gravitational forces that exist between two celestial bodies. It can be said that barycenter is a region in space where the gravitational forces exerted by two celestial bodies are perfectly balanced and the two bodies revolve around it maintaining a fixed distance from each other (as forces are balanced). So barycenter is the point at which the gravitational forces exerted by two objects are equal. But what happens when there is a system of more than two gravitationally interacting bodies and among them one body is large enough to have strong gravitational influence on other bodies? Solar system is an example of such system. In this system not only Sun and planet interact but also different planets gravitationally interact with each other [2]. If any two planets gravitationally interact with each other than those two planets will also be forming barycenter between them. Taking an example of Mars and Jupiter, barycenter is not considered to exist between them when they interact gravitationally because both of these planets revolve around the Sun whose gravitational force is strong enough to suppress the orbital motion of two planets around each other and compel the two planets to revolve around the Sun. So it can be said "there is a formation of barycenter between two planets which happen to interact gravitationally with each other".

### Theoretical Framework

#### Reasons for the formation of asteroid belt

By using barycenter formula for two bodies, we find that barycenter of Mars and Jupiter lies somewhere (exact position cannot be found as gravitational force of the Sun would also have a combined effect) between their orbits (outside the body of Jupiter) which is the point of balance of their gravitational forces [3]. This is actually a region where strong effect of combined gravitational forces of Mars and Jupiter exist. It gives result i.e., "Any small body bounded by its own weak gravitational

force (not bounded chemically or physically) when passes through the barycenter of Mars and Jupiter, its motion will be disturbed violently". This result is deduced from the Lagrangian points. Lagrangian point is the region in space where combined effect of gravitational forces of two large bodies balance and stabilize the relative motion of third very small body, so the reverse of it i.e., the point of balance of two very large bodies (barycenter) can result in violently disturbed motion of third very small body due to strong effect of combined gravitational forces present [4]. In case of Lagrangian points, the two large bodies balance the third very small body while in case of barycenter; the two large bodies balance each other and can disturb the motion of third very small body. It further gives result i.e., "Barycenter will act as a vortex in space in which if any small body enters the center of vortex, it will be equally pulled in all directions by the combined gravitational forces of two large bodies and will be tore apart into fine particles (like small particles in asteroid belt) but when small body is entering from any one side of the vortex such that one part of the small body is in the region of vortex and another part is outside the vortex then the part which lies outside will get separated from the part which has already entered the region of vortex [5]. The part of the small body in the region of vortex will be tore apart into fine particles while the part which got separated before it could enter the vortex will form pieces of small body which are relatively much bigger (e.g. formation of Ceres, Pallas, Vesta and Hygiea) than dust particles".

### Results and Discussion

This result is further verified from the observation of asteroid (6478) Gault made by Hubble Space Telescope in 2019. A small asteroid has been caught in the process of spinning so fast it's throwing off material, according to new data from NASA's Hubble Space Telescope and other observatories. Different observatories measured a two-hour rotation period for the object, close to the critical speed at which a loose

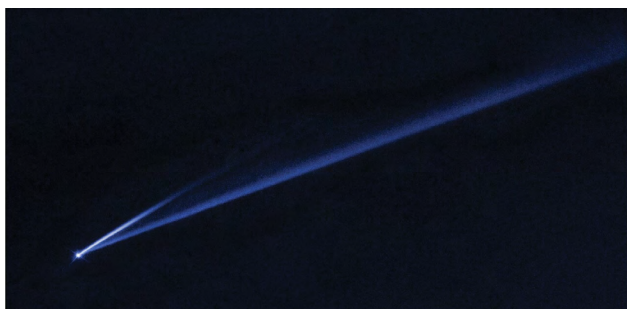
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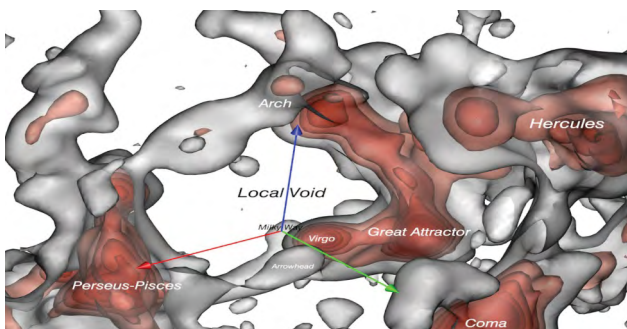
"rubble-pile" asteroid begins to break up (Figures 1-4). How violently an asteroid spins depends on the strength of the barycenter which will be maximum when Mars, Jupiter and Sun lie along the same line and Mars is at its aphelion and Jupiter at its perihelion. Gravitational force of the Sun would also enhance the combined effect of gravitational forces in the same way as in Lagrangian points.



**Figure 1:** This Hubble Space Telescope image reveals the gradual self-destruction of an asteroid, whose ejected dusty material has formed two long, thin, comet-like tails. The longer tail stretches more than 500,000 miles (800,000 kilometers) and is roughly 3,000 miles (4,800 kilometers) wide. The shorter tail is about a quarter as long. The streamers will eventually disperse into space. Credit: NASA, ESA, K. Meech and J. Kleyna (University of Hawaii), and O. Hainaut (European Southern Observatory).



**Figure 2:** The asteroid 6478 Gault is seen with the NASA/ESA Hubble Space Telescope, showing two narrow, comet-like tails of debris that tell us that the asteroid is slowly undergoing self-destruction. The bright streaks surrounding the asteroid are background stars. The Gault asteroid is located 214 million miles from the Sun, between the orbits of Mars and Jupiter. Credit: NASA, ESA, K. Meech and J. Kleyna (University of Hawaii), O. Hainaut (European Southern Observatory).



**Figure 3:** A smoothed rendition of the structure surrounding the Local Void. Our Milky Way galaxy lies at the origin of the red-green-blue orientation arrows (each 200 million lightyears in length). We are at a boundary between a large, low density void, and the high density Virgo cluster. Credit: R. Brent Tully.



**Figure 4:** Barycenter in the gravitationally bound system (such as galaxy or solar system) will form a web-like structure.

### Side results drawn from the study

In the present day solar system we cannot observe the barycenter between different planets but in a protoplanetary disk vortices will be observed (barycenter will act as a vortex and will agitate the gas around it) by the time when planets have already been formed in it.

Strength of the barycenter depends on the masses of the number of bodies (as barycenter can be a point of balance of more than two bodies). Massive the bodies, the stronger the region of barycenter is such that no other body will form a stable condition there and will be violently moved away. It gives the result that barycenter of two or more than two very massive bodies will act as a void (with no or very less mass) due to strong gravitational influence there. This result is verified by the observation of our Universe as a large "Local Void" has been found that borders the Milky Way Galaxy. Barycenter in the gravitationally bound system (such as galaxy or solar system) will form a web-like structure.

This web-like structure will maintain proper distance among the celestial bodies. Just like the intricate web of the spider which is least disturbed by the wind flowing through it due to its complex structure, web structure of the gravitationally bound system will keep the expansion of the Universe from increasing distances among the astronomical bodies. Moreover, tug of war effect created by barycenters will force the celestial bodies to revolve in the same direction in which the other celestial bodies with which they are making barycenters are revolving [6].

All the theoretical results shown, explain that how asteroid belt between Mars and Jupiter formed. Asteroid belt formed when small different rocky bodies passed through the barycenter of Mars and Jupiter. As a result, these small bodies tore apart into small pieces due to strong gravitational pull from all directions in the barycenter.

### Conclusion

In case of terrestrial planets only e.g. between Mercury and Venus, the above explained phenomenon might not be possible because of their small masses the combined effect of their gravitational forces is not strong enough to form any prominent belt of rocky pieces. While

in case of massive gaseous planets, there lies the possibility in the form of Kuiper belt (members of the Kuiper belt are mostly frozen volatiles) i.e., it could be the possibility that the region of gaseous planets in the rotating disc during the formation of solar system might contain small gaseous bodies which when passed through the barycenter of gaseous planets resulted in the formation of frozen volatiles (of Kuiper belt). Similarly members of the asteroid belt are mostly rocky in nature which gives the conclusion that their parent small bodies were from the region of terrestrial planets in the rotating disc which had passed through the barycenter of Mars and Jupiter.

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