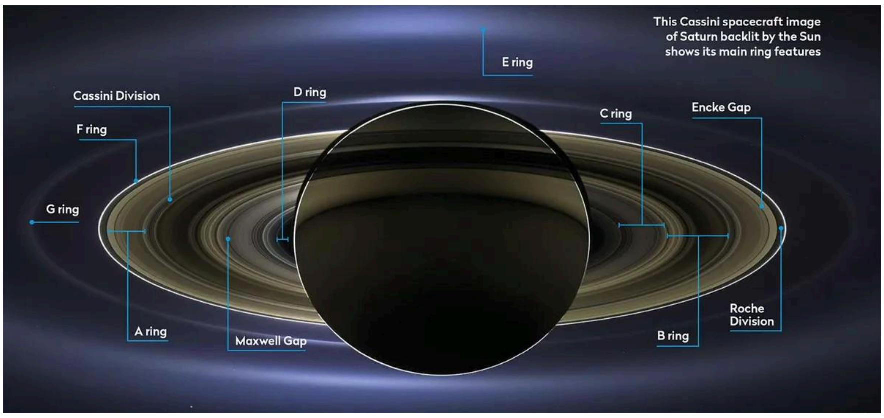
Where Did Saturn's Rings Come From?

By: Samantha Pradhan

<u>Information on Saturn & its rings</u>

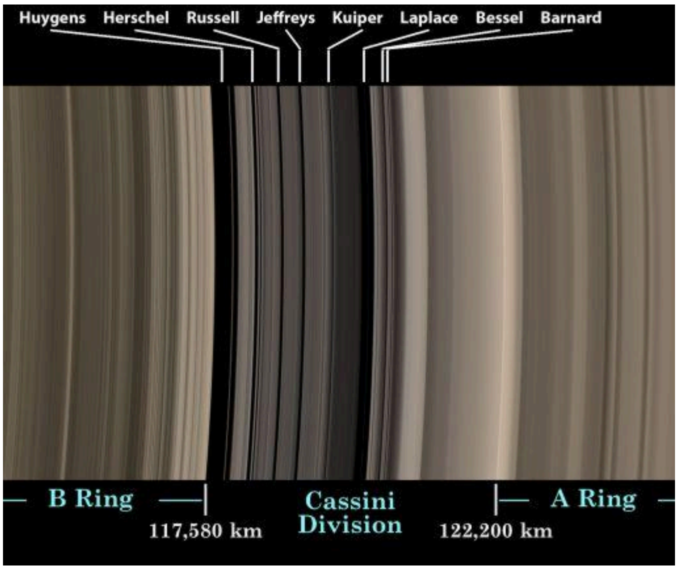
Saturn is the second-largest planet in our solar system, with a diameter of 120,000 km, but it is also the lightest due to its gaseous composition of primarily hydrogen and helium, the same components that make up our Sun. The average density of Saturn is only about 0.69g/cm^3, which is less dense than water (1g/cm^3). This theoretically means that if you could place Saturn in an ocean, the planet would be able to float!

Observations from the Cassini spacecraft mission revealed that the total radial breadth of Saturn's main rings spans approximately 282,000 km, with a thickness of only 10 meters. The 7 main rings are named alphabetically based on when they were discovered. The main rings are A, B and C, while D, E, F and G are fainter.



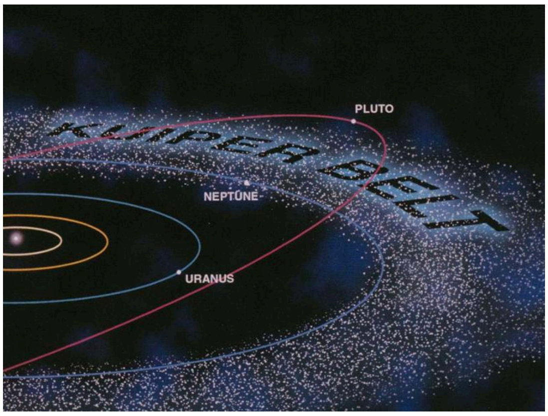
credits: NASA / JPL / SSI

Within the rings, there are numerous gaps. The largest one we can observe is called the "Cassini Division", discovered by the French astronomer, Jean D. Cassini in 1675. It separates the outer A ring from the inner B ring. However, it's not solely just empty space between the rings, but rather just a significantly less dense abundance of the ring particles that's present elsewhere.



credits: NASA / JPL / SSI

Further analysis determined that the rings are composed of 90-95% water-ice particles, with the remaining consisting of dust, rocky particles, silicates, metals, and other particles likely originating from the Kuiper Belt — the region of icy bodies beyond the orbit of Neptune.



credits: NASA

This composition was surprising, as prior theories had suggested that the rings would be predominantly rocky in nature. These earlier theories had proposed that the rings formed during the accretion of debris when Saturn itself was forming over 4.5 billion years ago. However, the composition of mainly water-ice in the rings points to a more recent origin, likely within the last 10-100 million years. This rules out the idea that the rings formed concurrently with the planet itself. Instead, the ice-dominated composition suggests the rings are the remnants of a disrupted moon, asteroid, or comet that was pulled apart by Saturn's gravity. The trace amounts of other volatile materials like carbon, sulphur, and organics present in the rings further support this more recent formation hypothesis, as these compounds would have been lost if it were over longer timescales.

Origin theories of Saturn's rings

Remnants of a destroyed moon, asteroid or comet:

The Cassini spacecraft conducted extensive observations of Saturn; its atmosphere, rings, moons, etc. From the findings, it was also hypothesised that the rings of the gas giant formed when it absorbed one of its icy moons or a nearby asteroid due to its immense gravitational pull and the satellite's proximity. During the process, Saturn's strong gravitational force would have stripped the icy surface of the satellite, which remained in orbit. Afterwards, the debris of the destroyed moon, asteroid or comet would coalesce to form the broad, extensive rings we now observe.

credits: BBC's The Planet

Collision of two moons:

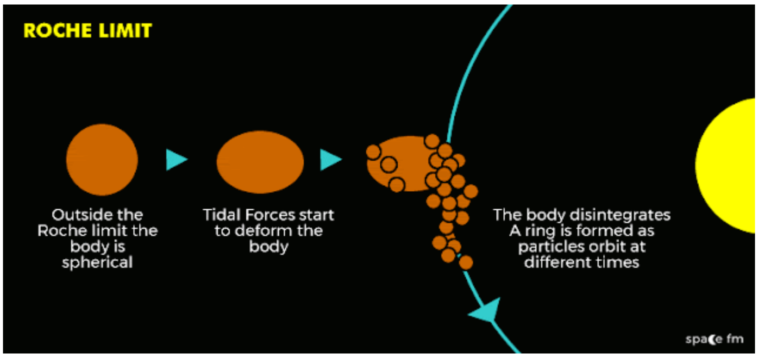
From recent research by NASA and its partners, the formation of Saturn's rings could have been due to the collision of two precursor icy moons. The collision could have been due to what is called a ***resonance***, where the gravitational forces of the Sun combine with that of Saturn, resulting in the destabilization of the icy moons' orbits, until their paths cross and eventually collide.

A supercomputer simulation on the collision of two icy moons: [Exploring the Origins of Saturn's Rings and Moons - NASA's Ames Research Center]

A still image from the simulation:

credits: NASA / Durham University / Glasgow University / Jacob Kegerreis / Luís Teodoro

The aftermath of the collision scenario shattered the right amount of ice that was within Saturn's ***Roche limit***. The Roche limit is the farthest distance from which a planet's natural satellite will disintegrate due to the planet's gravitational pull.



credits: space.fm

Through the collision of two moons, Saturn's rings would primarily be composed of water-ice rather than rocky particles, supporting the fact that they formed relatively recently rather than concurrently with Saturn itself.

The initial collision of the icy moons that formed Saturn's rings also likely hit other moons in the system, causing a chain reaction of collisions. This effect may have impacted other precursor moons outside the rings, and be the building blocks for the moons we see today. This makes them relatively young and composed mainly of water ice. For instance, Rhea, one of Saturn's 18 moons, orbits just beyond the region where it would have encountered a resonance. Normally, a satellite would drift away from the planet over time, and an ancient Rhea would have crossed this resonance, experiencing the destabilizing effects. However, Rhea's orbit is very circular and flat, suggesting it formed more recently, without going through the process of orbital resonance.