

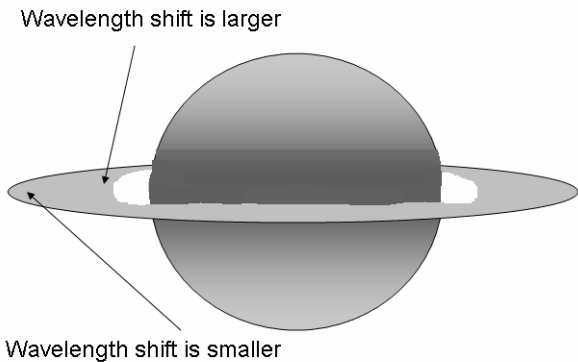
Rings are very common around the large planets in the Solar System. Saturn's ring are the most visible and the best studied. The picture at the left shows an image taken by the Cassini mission. The bright object is a distant star in the background.

1. What does the visibility of a star through the ring suggest about the character of the ring?

Since the star can be seen through the rings, the rings must not be solid or opaque. They could be an extremely thin solid sheet (but such a thin sheet is not very likely to survive).

2. That Saturn's rings are a collection of particles rather than solid can also be proven using the power of spectroscopy. Sunlight reflects well off Saturn's rings. If we record a spectrum from a region close to Saturn and more distant, we find that the wavelength shifts are larger close to Saturn and smaller at the outer edge of the rings as shown in the picture below. Recall that wavelength shifts are proportional to velocities and recall Kepler's Laws which tell us that objects close to a large parent object move faster than those further

away. How could these concepts be used to test whether the rings are solid or comprised of many particles? [Hint, how would velocities change with distance if the rings were solid?]



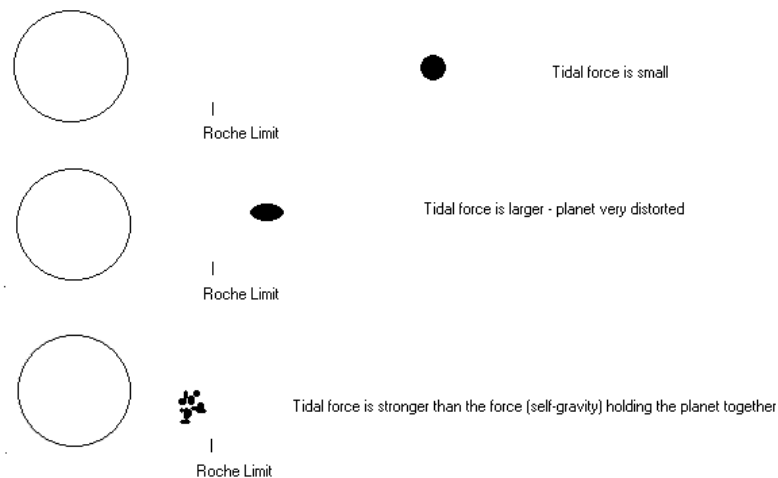
By using our knowledge of Doppler shifts, we know that the inner ring moves faster than the outer edge because wavelength shifts are larger for larger velocities. If the rings were a solid structure, then the velocities would have to be the same or it would tear itself apart. The wavelength shifts would be all the same in this case.

Measurements using radar and other techniques have shown that the particles that comprise the rings around Saturn are small enough that the rings must be replenished or the rings would have disappeared over the life of the Solar System. Alternatively, the rings may be some sort of episodic phenomenon and appear only from time to time, say when moons collide with other objects.

3. If rings are the result of some chance event like a collision between a moon and a large meteor, would you expect all of the giant planets to have rings now? What other information would be useful in deciding whether this is the right picture for formation of rings?

Whether all the gas giants would likely have rings due to collisions depends on the probability of a collision. This in turn depends on how many bits of stuff are floating around in the outer Solar System that are large enough to cause a collision where a moon could get smashed. This is the piece of information that would be nice to have.

Another model for the formation of rings and one that is more natural in view of rings being common around giant planets is the model where the strong gravitational field of the planet will tear an object apart if it gets too close.



If the difference in gravitational force on the near and far sides of a moon or other object orbiting a planet is greater than the force holding the object together, it will be torn apart and form a ring. A key part of this idea is the phrase “greater than the force holding the object together”.

4. What force is responsible for holding moons, planets and stars together?

Gravity is what holds objects like moons, etc. together.

The space shuttle orbits the Earth at a relatively low altitude, well within the Roche limit for the Earth.

5. Why isn't an object like the space shuttle torn apart by the same process that forms rings?

The space shuttle is not held together by gravity but rather by the strength of materials like the steel from which it is built. The strength of metals is provided by electromagnetic forces which are much stronger than gravity (but only important for short distances).