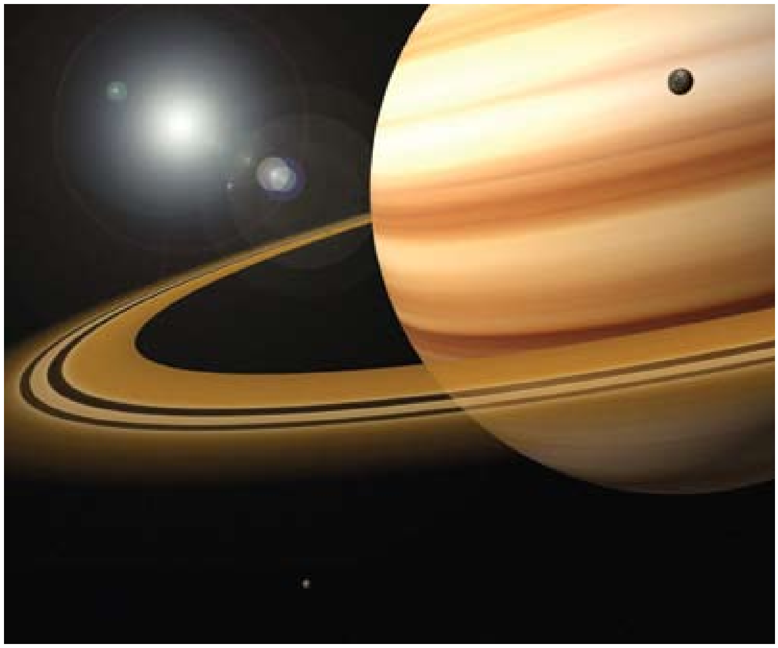
Of moons and rings

by Bob Riddle



When the planet Saturn is mentioned, most probably picture the spectacular rings above the planet's equator. The rings are not unique to Saturn (planetary rings encircle the four Jovian planets), but they are the only ones visible from Earth. Despite the compelling beauty and mysteries of ring systems and the dynamics that add to their allure, the incredible variety among the many moons of these planets is equally exciting.

Saturn is our working model for a ring system because of its proximity and the presence of the *Cassini* spacecraft in the Saturnian system. Saturn's rings are composed of bits of ice and rocks ranging from dust and sand sized to boulder sized. The rings are near-perfect circles and the particles making up the rings lie essentially on the same plane, making Saturn's ring system very thin when compared with the diameter of the rings. While the diameter is approximately the same as the Earth-to-Moon distance—270,000 km—the rings measure only in the tens of meters in thickness. It is thought that interactions and collisions between the individual ring particles force the particles into circular orbits along the same plane.

The rings are made of individual particles—each of which is a satellite, or a moon, with its own orbit around the planet. Particles in the innermost rings orbit the planet faster than those further out. There are thousands of rings (ringlets), but from Earth the rings appear to be solid with some gaps. These gaps or spaces between the rings are caused by gravitational interactions among the larger ring particles, small moons, and the particles along and near their orbital path. Sometimes known as *shepherd moons*, or *gap moons*, these larger ring particles can nudge smaller ring particles so that they bunch up and form a narrow ring, or the ring particles clear out, leaving a gap in the rings. Ring particles are also influenced by the tidal forces of the larger, more distant moons orbiting Saturn.

While the rings around Saturn, like the rings around other planets, were formed by and are maintained by similar processes, questions still remain about where the ring particles come from and how it is that the rings are still in place.

One idea is that a large moon somehow came too close to the planet, within the Roche limit, or Roche tidal zone, and broke apart from the gravitational forces from the planet, forming the ring system. However, the chance of all four of the planets having a large moon come within the Roche limit and break up to form the rings is unlikely. Another idea that initially makes sense is that the rings are composed of leftover material from the planet-forming period. Gravity or tidal forces again would have been involved, this time by preventing these particles from coalescing into moons, thus leaving thousands of particles in orbit forming the rings. Given the time that has passed since then, these particles should have long since been ground to dust from the constant collisions. Consequently, the dust-sized particles would have been more easily influenced by tidal forces from the more distant and larger moons, as well as from the pressure of the solar wind. Over time, the dust-sized particles would have slowed and fallen into the planet. So if the source of the rings was the breakup of a moon or leftover material from planetary formation, then the rings should probably no longer be there.

THINKING INSIDE THE BOX

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Answering where rings come from may not be as easily done as explaining how the rings are maintained. Some believe that the ring particles come from constant collisions. Larger moons collide to form many smaller moons that then have their own collisions, producing even smaller pieces, and so on, in a never-ending process of collisions and reduction in size. It is important to realize that because the ring particles, of all sizes, are moving in the same direction and more or less the same speed within each ring, the collisions are probably not that powerful or regular but more like particles randomly brushing against each other. On the other hand, any particle without a more inclined or elliptical orbit will intersect a ring at some time, and will likely have a more powerful collision. Nevertheless, collisions, while constant, are not happening all of the time, so the amount of ring material produced from collisions is not constant.

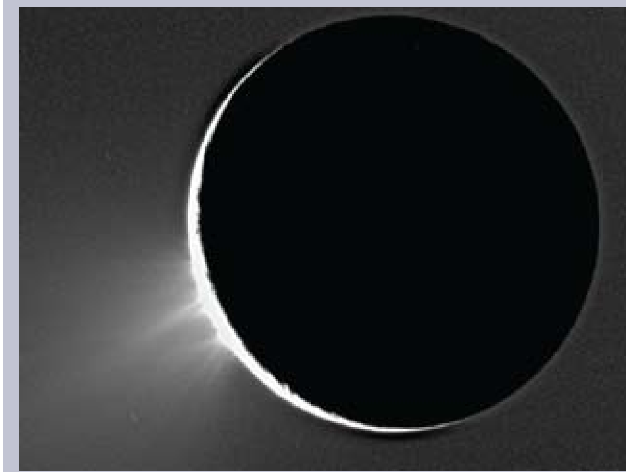
Another source of ring particle material appears to come from some of the icy moons orbiting the planets. These moons are predominantly icy in composition and have interiors that are warmed from tidal forces from the planet they orbit and from companion moons with larger sizes and masses. In effect, these moons are as geologically active as is the Earth, for example, but due to external forces rather than internal forces. The internal warming from external tidal forces creates volcanic conditions on the moon's surface. However, at the very low temperatures found in this part of the solar system, it is not molten rock erupting, but ice and vapor from semiliquids of water and ammonia. This type of cold volcanic activity is known as *cryovolcanism*. Saturn's moon, Enceladus, has been observed by the *Cassini* spacecraft to have icy geysers spewing material from its south polar region. Much of the material falls back to the surface, but there is enough energy from these eruptions to propel material into space.

Enceladus is not the only cryovolcanically active moon. There are at least several other moons exhibiting cryovolcanic activity, including Saturn's largest moon Titan, and Neptune's largest moon Triton, and indirect evidence of similar activity on other moons and even on some of the Kuiper belt objects.

Visible planets

Mercury will move from the eastern horizon before sunrise in April to behind the Sun, and will reemerge in the evening skies for a well-placed viewing opportunity during May.

FIGURE 1 Icy fountains on Enceladus as seen from the *Cassini* spacecraft



Venus will be low over the eastern horizon at sunrise and difficult to see as it moves toward inferior conjunction between the Earth and the Sun in early June.

Mars will be visible over the south-southwest horizon and will set several hours after sunset.

Jupiter will rise around midnight and will be very visible, shining brightly over the southern horizon at sunrise.

Saturn will be located in the constellation Leo near the bright star Regulus, both of which set after midnight.

Celestial events

April

4/5	Moon near Venus
4/6	New Moon
4/8	Moon near Pleiades
4/11	Moon near Mars
	First quarter Moon
4/12	Moon near the Twins
4/14	Moon west of Regulus and Saturn
4/15	Moon east of Regulus and Saturn
4/16	Mercury at superior conjunction
4/20	Full Moon
4/27	Moon near Jupiter
4/28	Last quarter Moon

May

5/5	New Moon
5/9	Waxing crescent Moon near the Twins
5/10	Moon near Mars

5/12 First quarter Moon
Moon near Saturn
5/14 Mercury at eastern elongation
5/16 Moon near Spica
5/20 Full Moon
Moon near Antares
5/24 Moon near Jupiter
5/28 Last quarter Moon

Questions for students

1. What would explain why there are no relatively large moons within the rings? *(Due to constant collisions between ring particles there are no large moons.)*
2. Because ring-particle collisions happen randomly, how would this affect the appearance of the rings over time? *(The rings would change in appearance, as the amount of ring material produced varies due to the randomness of collisions.)*
3. Where are some places besides the Earth where there are active volcanoes? *(Volcanism of the molten-rock type is found on Earth, Venus, and Jupiter's moon Io. Cryovolcanism is found on some of the icy moons of the outer solar system like Enceladus, Triton, and Ariel.)*
4. Why do we not find icy moons in the inner part of the solar system? *(The inner solar system had temperatures too high for icy objects to form or to remain solid.)*

Resources

Cassini at Saturn—*http://saturn.jpl.nasa.gov/home/index.cfm*
Cassini educational materials for middle school—*http://saturn.jpl.nasa.gov/education/edu-58.cfm*
Fountains of Enceladus—*http://photojournal.jpl.nasa.gov/catalog/PIA07758*
SFA star charts—*www.midnightkite.com/starcharts.html*

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