PLANETARY RINGS

Ever decreasing circles

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THE most conspicuous and, until recently, the only known planetary rings in the Solar System, those around Saturn, may be the remains of a comet that came too close to the planet and was torn apart by tidal forces, Luke Dones argues in *Icarus*[1]. In doing so, he nearly revives an old suggestion, proposed by Edouard Roche in the last century, that the rings comprise the debris of a moon destroyed in the same way.

The origin of the rings surrounding the planets has, if anything, become a deeper puzzle over the years. In part, this is because, since 1977, rings have been discovered around each of the giant planets Jupiter, Uranus and Neptune, so that Saturn is no longer unique. Moreover, detailed measurements by the Pioneer and Voyager spacecraft have overthrown the old prevailing idea that the rings were formed at the same time as the planets: the evidence shows that gravitational torques and micrometeoroid erosion quickly destroy the rings, which are typically only 100 million years old, barely 2 per cent of the age — 4.5 billion (10^9) years — of the planets. If the rings are so shortlived, they must be continually replaced for them still be visible.

One possibility[2,3] is that rings are created whenever a small moon is destroyed in a collision with a comet or asteroid. The moons would themselves be the fragmentary remains of a previous collision involving a larger parent moon. Thus the rings would be the smallest in a cascade of fragments, including unseen tiny moons, orbiting the giant planets[4]. Indeed, Voyager detected a multitude of small moons, including Saturn's recently discovered satellite[5], Pan, among the planetary rings. And the presence of yet more can be deduced through their effects on the rings[6]. The continuing creation of rings and dust envisaged in this hypothesis would balance the steady loss responsible for the rings' youth.

Although collisional disruption could explain the rings around Jupiter, Uranus and Neptune, Saturn's rings pose a problem. They are so massive that creation by break-up of one of Saturn's moons is very unlikely. The moon would have had to be as large as Saturn's present moon Mimas (with a radius of 193 km): because such large moons are held together strongly by their own gravity, the likelihood is only about 1 per cent that one would have been destroyed in the past 100 million years.

Dones investigates the alternative hypothesis — that Saturn's rings were formed by tidal disruption of a comet that passed too close to the planet. Within the region now bounded by Saturn's rings, a comet could be broken up by tidal forces and many of the fragments would be captured by Saturn's gravity. The proportion of material captured would depend on the viscosity of the comet, its speed and how close it passed to Saturn. Dones estimates that up to 44 per cent of a comet of radius 500 km could be captured. Within 100,000 years, collisions between the cometary fragments and with Saturn's moons would create smaller fragments whose orbits converge to form a ring.

The model's main drawback is the number of comets approaching Saturn from observations of the object Chiron, whose eccentric orbit crosses those of Saturn and Uranus, Dones predicts that Saturn has had between 10 and 100 close encounters with a comet in the age of the Solar System. Of these, only about one would have left enough debris to form the rings. This formation frequency is similar to that estimated for collisional destruction; in either case, the creation of Saturn's rings is an unlikely event.

In support of collisional creation, Dones notes that the rings are reflective and made of nearly pure water ice; they therefore resemble the inner moons of Saturn and not the dark, dusty comets in their composition. The rings also rotate prograde, that is, in the same direction as Saturn's moons. Because a captured comet has a 50 per cent chance of creating a retrograde (oppositely) rotating ring, this is a weak argument in favour of the collisional model. But the tidal model predicts that cometary fragments striking Saturn's inner moons would leave a distinctive crater population, and Dones points out that such a population ('population II') has been observed on the moons Mimas, Dione and Rhea[7]. On balance, we must conclude that the existing observations leave the origin of Saturn's rings undecided.

The tidal model could actually be much more plausible than the collisional model if astronomers have underestimated the number of comets near Saturn. But if comet capture were ten times more likely we would expect that Jupiter, Uranus or Neptune would also have captured a massive ring like Saturn's, as Saturn is not favoured in this particular lottery. Therefore, the present existence of Saturn's rings would still remain unlikely.

Unless we have misunderstood the rapid evolution and short lifetimes of planetary rings (which will be checked by future observation by the Hubble Telescope and the NASA–ESA Cassini mission to Saturn), we must consider ourselves lucky whenever we see Saturn's rings: in the cosmic sense, they are both a rare and a beautiful sight. □

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A planetary flash in the pan? Saturn's apparently shortlived rings, as captured by Voyager I in 1979. Computer suppression of the three brightest rings allows nearly 100 to be apparent.

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1. Dones, L. *Icarus* **92**, 194–203 (1991).
2. Esposito, L. W. *Icarus* **67**, 345–357 (1986).
3. Esposito, L. W. & Colwell, J. E. *Nature* **339**, 605–607 (1989); Erratum, *Nature* **340**, 322 (1989).
4. Colwell, J. E. & Esposito, L. W. *Icarus* **86**, 530–560 (1990); *Geophys. Res. Lett.* **17**, 1741–1744 (1990).
5. Showalter, M. *Nature* **351**, 709–713 (1991).
6. Murray, C. D. & Thompson, R. P. *Nature* **348**, 499 (1990).
7. Lissauer, J. J., Squayres, S. W. & Hartmann, W. K. *J. Geophys. Res.* **93**, 13776–13804 (1988).