



The rings of Uranus (top right) and Neptune (bottom right) are similar to those of Jupiter and consist millions of small rocky and icy objects in separate orbits. The figure shows a comparison of the scales of the planets and their ring systems.

Problem 1 – Compare the extent of the ring systems for each planet in terms of their size in units of the radius of the corresponding planet. For example, ‘The rings of Uranus extend from 1.7 to 2.0 times the radius of Uranus’.

Problem 2 – An icy body will be destroyed by a planet if it comes within the Tidal Limit of the planet. At this distance, the difference in gravity between the near and the far side of the body exceeds the body’s ability to hold together by its own gravity, and so it is shredded into smaller pieces. For Jupiter (2.7), Saturn (2.2), Uranus (2.7) and Neptune (2.9), the Tidal Limits are located between 2.2 and 2.9 times the radius of each planet from the planet’s center. Describe where the ring systems are located around each planet compared to the planets Tidal Limit. Could the rings be explained by a moon or moon’s getting too close to the planet?

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Answer: Jupiter from 1.4 to 2.3
 Saturn from 1.1 to 3.6
 Uranus from 1.7 to 2.0
 Neptune from 1.7 to 2.7

Problem 2 – An icy body will be destroyed by a planet if it comes within the Tidal Limit of the planet. At this distance, the difference in gravity between the near and the far side of the body exceeds the body’s ability to hold together by its own gravity, and so it is shredded into smaller pieces. For Jupiter (2.7), Saturn (2.2), Uranus (2.7) and Neptune (2.9), the Tidal Limits are located between 2.2 and 2.9 times the radius of each planet from the planet’s center. Describe where the ring systems are located around each planet compared to the planets Tidal Limit. Could the rings be explained by a moon or moon’s getting too close to the planet?

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|-----------------|-----|-------|-------|-------|
| Answer: Jupiter | 1.4 | 2.3 | (2.7) | |
| Saturn | 1.1 | (2.2) | | 3.6 |
| Uranus | 1.7 | 2.0 | (2.7) | |
| Neptune | 1.7 | | 2.7 | (2.9) |

The location of the tidal radius for each planet is given in parenthesis on this scaled model. We see that for all of the planets, most of the ring material is located inside the Tidal Limit. In the case of Saturn, which seems to be the exception, there is also some ring material outside $R = 2.2 R_s$ and includes the very sparse F and G rings. But even for Saturn, the majority of the visible rings (seen through a telescope) are inside the Tidal Limit.

The rings can be explained by moons that were tidally destroyed as they passed inside the Tidal Limit for each planet. These moons could not have been formed this close because the same tidal forces that destroy these moons would have prevented them from assembling, so the moons must have been formed outside the Tidal Limit and over millions of years their orbits carried them closer and closer to the Tidal Limit until they were finally destroyed.