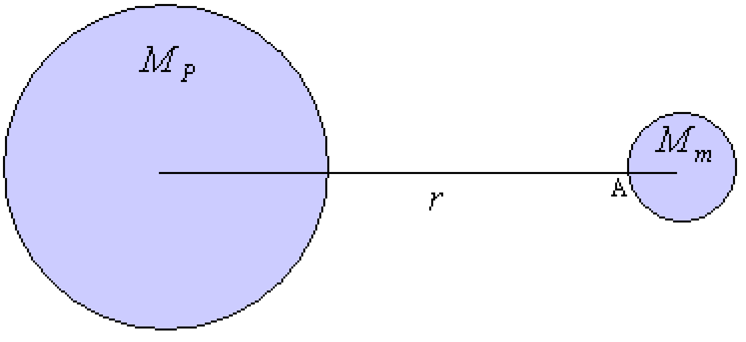
How do ring systems form?

The ring systems of the Jovian planets are the result of **tidal forces**. During planetary formation, tidal forces prevented any material (planetesimals) that was too close to the planet clumping together to form moons. Also, any moons formed further out which later strayed too close to the planet would be tidally disrupted.

We can estimate the orbital radius at which a moon will break apart, due to tidal forces. Consider a moon, of mass M_m and radius R_m, in a circular orbit of radius r from a planet of mass M_P and radius R_P



Assume for simplicity, spherical planet and moon

Force on a unit mass at A due to gravity of **moon alone** is

$$F = \frac{GM_m}{R_m^{\,2}}$$

Tidal force at A due to gravity of **planet** is *

$$F_T = \frac{2GM_P R_m}{r^3}$$

* Putting $dr = R_m$

We assume, as an order-of-magnitude estimate that the moon is tidally disrupted if

$$F_T > F_G$$

i.e.

$$\frac{2GM_P R_m}{r^3} > \frac{GM_m}{R_m^{\,2}}$$

Substituting $M_P = \frac{4\pi}{3}\bar{\rho}_P R_P^{\,3}$ and $M_m = \frac{4\pi}{3}\bar{\rho}_m R_m^{\,3}$

$\Longrightarrow$ Moon is tidally disrupted if

$$r < 2^{1/3}\left(\frac{\bar{\rho}_P}{\bar{\rho}_m}\right)^{1/3} R_P$$

More careful stability analysis

$$r < 2.456\left(\frac{\bar{\rho}_P}{\bar{\rho}_m}\right)^{1/3} R_P \quad = \quad \text{Roche Limit}$$