Exercise session - 'Astronomy'

24.05.2017

1 The Asteroid Belt

Science fiction movies are mostly rather fiction than science. A good example is the classical depicition of the asteroid belt as a dangerous zone between Mars and Jupiter that inevitable leads to collions with large objects. What is the scientific thruth?

a) Suppose there are 600,000 objects in the belt with a mean diameter of 100 km. What is the approximate total volume of these asteroids?

b) If the belt stretches from 2 AU to 3 AU with a thickness of $2R_\odot$ ($R_\odot \approx 700,000$ km). What is its volume?

c) What fraction of the belt is really covered by asteroids?

2 The Roche Limit

1. A steel rod of length 1 m and a diameter of 1 cm^2 radially travels towards a neutron star with a mass of $1.4M_\odot$. The ultimate tensile strength of typical steel is around $\sigma \approx 510$ N/mm^2 whereas its density reads $\rho = 7.86$ g/cm^3. What is the maximal distance to the neutron star's center the rod can go without being disrupted? (Recall: $M_\odot \approx 2 \cdot 10^{30}$ kg)

2. In general, comets are assumed to possess a mean density of $\bar{\rho} = 1$ g/cm^3.
   a) What is the minimal distance to the Sun a comet can have without being disrupted?

   b) A comet happily passed by the Sun in a distance of ~ 0.15 AU. What does this imply for its mean density?

3 The Curious Case of Io

Io is one of the four Gallilean moons of Jupiter ($M_{♃} \approx 1.9 \cdot 10^{27}$ kg, $a_{♃} \approx 5.2$ AU). It orbits around its host planet on a nearly circular orbit of radius $a = 422,000$ km.

a) Given Io's mean density of $\overline{\rho} = 3.528$ g/cm^3, what is the Roche Limit you would expect for this moon? Why is Io still there?

b) The mean surface temperature on Io is about -143°C. We know that the albedo of Io is $A = 0.61$. As this moon possesses only a very thin atmosphere, estimate the surface temperature using the luminosity of the Sun $L_{\odot} = 3.845 \cdot 10^{26}$ W! Can you guess what sources are responsible for the difference?