Exercise session - 'Astronomy'

26.04.2017

1 Local Solar Time

The coordinates of Polaris are $\alpha = 2\,\mathrm{h}\ 31.9\,\mathrm{min}$ and $\delta = 89°\ 15.9'$. Find the apparent sidereal time at the moment Polaris is in upper culmination as you would observe it in Ljubljana (46° 03′ N, 14° 30′ E). Express the result in local solar time assuming the observation date to be tomorrow (27th April).

Remark: Since sidereal time Θ is the hour angle of the vernal equinox ♈, it is 0 h when ♈ culminates or transits the south meridian. At the moment of the vernal equinox, the Sun is in the direction of ♈ and thus culminates at the same time as ♈. So sidereal time at 12 : 00 local solar time is 0 : 00, and at the time of the vernal equinox, we have

$$\Theta = T + 12\ \mathrm{h},$$

where T is the local solar time. This is accurate within a couple of minutes. Since the sidereal time runs about 4 minutes fast a day, the sidereal time, n days after the vernal equinox, is

$$\Theta \approx T + 12\ \mathrm{h} + n \times 4\ \mathrm{min}.$$

At autumnal equinox ♈ culminates at 0 : 00 local time and sidereal and solar times are equal.

2 Orbital Motion in the Solar System

Using Kepler's laws enables us to find various properties of the orbits of our Solar System's planets:

1. Determine the periapsis and apoapsis of Mercury ($M_{☿} = 3.301 \cdot 10^{23}$ kg) given its orbital eccentricity $e = 0.205635934$ and semimajor axis $a = 0.387099273$ AU. Find also the velocity of Mercury in perihelion and aphelion position as well as its orbital period ($M_{\odot} = 1.9884 \cdot 10^{30}$ kg).

2. Do the same tasks for Pluto ($M = 1.303 \cdot 10^{22}$ kg) but this time you know its periapsis $r_p = 29.658$ AU and apoapsis $r_a = 49.305$ AU.

3. Jupiter's moon Ganymed ($m = 1.4819 \cdot 10^{23}$ kg) revolves around its host plant in a nearly circular orbit of radius $r = 1070400$ km in about $P = 7.15455296$ d. What is the mass of Jupiter?

4. Derive an estimate of the mean density of the Sun.

Recall: 1 AU $= 1.496 \cdot 10^{11}$ m, mean angular diameter of the Sun in the Sky $\alpha = 32.15$'.

3 Escape velocity

Which is easier, to send a probe to the Sun or away from the Solar system given the orbital velocity of the Earth of about 30 km/s?