PHAS1202 Atoms, Stars & the Universe
Astrophysics PST 2: December 2017

The following may be assumed if required:

Planck constant	h	$= 6.63 \times 10^{-34}$ J s
1 eV		$= 1.6 \times 10^{-19}$ J
Proton mass		= 1.0078 amu
Helium mass		= 4.0026 amu
Mass of the Sun	$M_\odot$	$= 2.0 \times 10^{30}$ kg
Solar Luminosity	$L_\odot$	$= 3.8 \times 10^{26}$ W
Solar radius	$R_\odot$	$= 6.96 \times 10^{8}$ m
1 year	yr	$= 3.16 \times 10^{7}$ s
1 parsec	pc	$= 3.1 \times 10^{16}$ m
Speed of light	c	$= 3.0 \times 10^{8}$ m s^{-1}
Gravitational constant	G	$= 6.67 \times 10^{-11}$ m^3 kg-1 s^{-2}
Hubble constant	H_o	$= 75$ km s^{-1} Mpc^{-1}
Constant in Wien's law	=	3×10^{-3} m.K

1. By first deriving the H to He mass deficit, calculate the main sequence lifetime (in years) of a 5 $M_\odot$ star if it has a luminosity of 600 $L_\odot$ and 10% of its mass is converted from hydrogen to helium.

2. What are the differences in appearance between a SBc galaxy and a Sa galaxy.

   At what redshift is the Lyman$-\alpha$ line (rest wavelength 121.6 nm) brought into a visible light detector that is sensitive to photons of wavelength greater than 370 nm?

   Quasar 3C 273 has a redshift of 0.16. Calculate its distance in units of Mpc.

3. The Andromeda, has a luminosity (intrinsic brightness) 3 times as bright as the Luminosity of our Milky Way galaxy, and is at a distance = 0.7 Mpc. The flux we observe from the Andromeda galaxy (apparent brightness) is 10,000 times brighter than the flux observed from a distant quasar. This quasar has a luminosity that is 1000 times the luminosity of our Milky Way galaxy. What is the distance to the quasar?

4. Suppose a star orbits its galactic centre at a distance of 8.5 kpc and that the mass of the galaxy contained within that circular orbit is 1.2×10^{11} $M_\odot$. Calculate the star's orbital velocity (in km s^{-1}) and hence its orbital period (in years).

5. The expansion of the Universe only takes place on very large physical scales (much larger than galaxies). But for now imagine that it holds on scales comparable to the Earth. Calculate by what distance a patch of intergalactic space as wide as the Atlantic Ocean (i.e. width 6000 km) would grow in a year under the expansion of the Universe. Compare with the actual growth of the Atlantic Ocean due to plate tectonics (you can Google that!).