ASSIGNMENT-1 (Due on Sep 7, 2018)

1. COORDINATE SYSTEMS: Proxima Centauri (α-Centauri C) is the closest star to Sun and is part of a triple system. It has the epoch 1950 coordinates (α, δ) = (14h 26.3m, -62d 29m) while the centre of the system is located at (α, δ) = (14h 36.2m, -60d 36m).

   (i) What is the angular separation of Proxima Centauri from the centre of the triple star system?

   (ii) If the distance to the Proxima Centauri is 4 x 10^{18} cm, how far is the star from the centre of the triple system?

   (iii) Precess the coordinates of Proxima Centauri to epoch 1990.

   (iv) The propermotion of Proxima Centauri is 3.84" yr $^{-1}$ with a position angle of 282^o. Calculate the change in α and δ due to propermotion between 1950 and 1990.

   (v) Which effect makes the largest contribution to changes in the coordinates of Proxima Centauri? Precession or Propermotion?

2. MAGNITUDE TO FLUX CONVERSION: Calculate the fluxes for three objects corresponding to the following magnitudes from SDSS (in AB system). you can use https://www.sdss.org/dr12/algorithms/magnitudes/ for details.

Band	Wavelength (Å)	Object 1 m(dm)	Object 2 m(dm)	Object 3 m(dm)
u	3543	20.19(0.08)	19.58(0.04)	19.95(0.03)
g	4770	18.21(0.01)	18.66(0.01)	19.42(0.01)
r	6231	17.20(0.01)	18.15(0.01)	19.40(0.01)
i	7625	16.73(0.01)	17.83(0.01)	19.09(0.01)
z	9134	16.35(0.01)	17.72(0.01)	18.93(0.04)

   Coordinate of the object 1: 21h59m33.62s+00d54m49.7s; 2: 21h57m59.04s+00d57m25.6s; and 3: 21h57m35.60s+00d58m16.6s. Our plot your fluxes on the spectra of these objects you can down load from http://skyserver.sdss.org/dr14/en/tools/explore/summary.aspx . You can take necessary help for this part from Soumak. First object is an elliptical galaxy, second one is a star forming galaxy and the third one is a high-z quasar.

3. TRIGONOMETRIC PARALLAX: Let us consider the stellar mass of our Galaxy (assumed to be a disk of radius 10 kpc and height 100 pc and made up of stars like Sun) is 10^{10} $M_\odot$. If 0.005" is our limit for measuring the trigonometric parallax then for how many stars you will be able to measure the distance from us using trigonometric parallax method? (Hint: stellar mass: total mass of stars in a galaxy).

4. MAGNITUDES: The faintest galaxies observed by the Hubble Space Telescope have apparent magnitudes around 30. Suppose these galaxies are ≈ 3 giga-parsecs away (10^9 parsecs). Assuming every star in these galaxies emits about the same amount of light as the Sun, how many stars would these galaxies contain? (Hint: Absolute magnitude of Sun is 5).

5. KEPLER PROBLEM: Consider a Sun-like star, which is orbited by a planet with a period of 80 years. If the separation of the star and the planet appears to be 20 arc seconds, how far away is the star from us?

6. HYDROSTATIC EQUILIBRIUM: Is hydrostatic equilibrium possible for constant density isothermal gas? Suppose the density profile is as given below then how the pressure as a function of r should behave so that one can have hydrostatic equilibrium.

$$\rho(r) = \frac{\rho(r_c)}{1 + (r/r_c)^2}$$

7. JEANS MASS: Calculate the Jeans mass and Jeans length of a spherical cloud of Hydrogen gas having density 1 cm^{-3} and temperature 10^4 K. If one completely ionise this cloud without changing the temperature what will happen to the cloud?

8. TWO BODY RELAXATION: Estimate the two-body relaxation time for stars in (i) our Galaxy (R = 15 kpc, v = 200 km/s, N = 10^{11}) assumed to be spherical in shape and in a Globular cluster (R = 5 pc, v = 30 km/s, N=10^6). Which of these systems can be considered collisionless and why? (Remember R = radius, v = rms velocity of the stars and N total number of stars).

9. SCHWARZSCHILD RADIUS: Estimate the gravitational radius of the Sun. To what density should the solar matter be squeezed before it becomes a black hole? If the mass of the object is instead 10^8 times the mass of the Sun, to what density does it have to be squeezed before it becomes a black hole?

10. GRAVITATIONAL LENSING: Show that if the distance D_s to the source is fixed, then the area $\pi D_L^2 \theta_E^2$ inside the Einstein radius is largest when the lens is midway between the source and the observer: $D_S = 2 D_L$. If the objects that might act as lenses are uniformly spread in space, a source is most likely to fall within the Einstein radius of a lens that is about halfway between it and the observer.

11. GRAVITATIONAL MICROLENSING: If the lens is a 1 $M_\odot$ object at distance D_L from us, find the Einstein radius of a star at a distance $D_S = 2 D_L$. As such Einstein rings are very small in size, gravitational lensing by compact objects in the halo of a galaxy is often referred to as gravitational microlensing.

12. GRAVITATIONAL AMPLIFICATION: Let the source be stationary, while the lens moves with proper motion μ milliarcsec per year; at time t = 0 they are closest on the sky, separated by an angle $\beta_0 \ll \Theta_E$. Show that at small separation, the sum of the images is brighter than the source by roughly a factor

$$\frac{F(image)}{F(sources)} \sim \frac{\theta_E/\beta_0}{\sqrt{(1 + (\mu t/\beta_0)^2)}}$$

13. HII Regions: A star emits 10^{48} photons per second. The star is embedded in an ISM (assume to be made only of Hydrogen atoms) of number density 1 cm^{-3}. Estimate the radius of the Strömgren sphere using basic assumptions discussed in the class. It is well known that 2/3 of hydrogen recombinations will end up in Ly α (i.e. line with a rest wavelength of 1215 Å). Estimate the Ly α luminosity from this H II region ignoring any optical depth effects.

14. Collisional ionisation of hydrogen: A hydrogen gas of density 10 cm^{-3} is in collisional ionisation equilibrium at a temperature of 10^3 K. Estimate the fraction of neutral hydrogen in this gas.

15. Understanding Redshifts: Consider a QSO at z = 3 whose intrinsic spectrum can be approximated with a powerlaw,

$$L_\lambda = 10^{43}(\frac{\lambda}{3000})^{-1}$$

If our line of sight to this QSO is intercepted by a HI cloud having a column density of $7\text{x}10^{16}$ cm^{-2} how the spectrum received in earth will look like. Consider only the continuum absorption. HINT: Hydrogen ionising cross-section as a function of frequency is

$$\sigma(\nu) = 6.8 \times 10^{-18}(\frac{\nu}{\nu_0})^{-3}$$

with ν_0 being the rest frequency corresponding to 13.6 eV (or wavelength 912 Å).