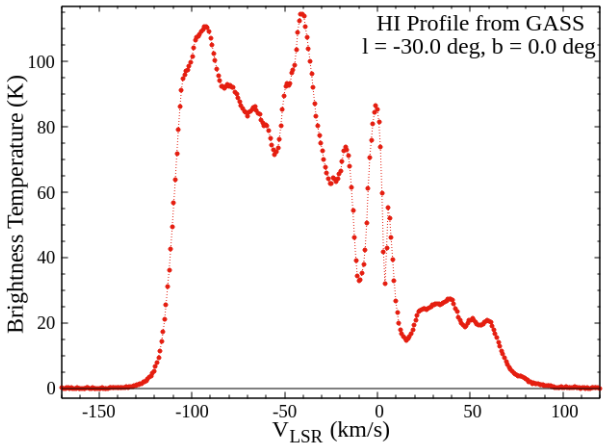
Mid-semester examination
PH 365 : Galaxies and ISM
February 21, 2019

Full marks: **50** Duration: **2 hours**

Answers must be brief and to the point.

Q.1 In the Shapley-Curtis debate, Curtis reached the correct conclusion on the nature of the spiral nebulae, using some right, as well as some wrong arguments. List **(a)** two key right arguments he used, and **(b)** two wrong arguments including **(c)** a brief discussion pointing out how he was able to reach the right conclusion even if the arguments were wrong. **4 + 4 + 2**

Q.2 Fig. (1) shows a typical Galactic HI 21 cm emission spectrum from the Parkes Galactic All-Sky Survey. For this line of sight, **(a)** what is the Heliocentric and Galactrocentric distance to the tangent point, and **(b)** what is the circular speed at the tangent point? Assume the circular velocity to be 220 km s^{-1} at the solar circle (8 kpc from the Galactic centre). **(c)** If the proper motion of the starts of a star cluster is μ, the "convergent point" of the cluster is at an angular separation θ from the current central position, and the radial outward component of the velocity is v_r , derive the distance to the cluster in terms of μ, θ and v_r , assuming a constant physical diameter of the cluster. **(d)** For the cluster Hyades, μ = 100 mas yr^{-1}, v_r = 40 km s^{-1} and θ = 33 deg. What is the distance in pc to this cluster and its space velocity? **2 + 3 + 2 + 3**



Q.3 Consider the measured values of the Oort's constants at solar neighbourhood to be A = 15.3 +/- 0.4 km s^{-1} kpc^{-1} and B = -11.9 +/- 0.4 km s^{-1} kpc^{-1}. Taking the distance to the Galactic centre to be 8 kpc, **(a)** what then is the circular velocity at that radius? **(b)** Show that these measured values are inconsistent with either solid body rotation or Keplerian rotation. **(c)** In this case, what will be the ratio of maximum radial and azimuthal displacements of the epicyclic motion of stars at solar neighbourhood in near-circular orbits? **(d)** Draw schematic isophote for elliptical galaxy for the cases when the leading terms of isophote deviation are a_2 and b_3 respectively. **2 + 3 + 3 + 2**

Q.4 **(a)** Write down the Collisionless Boltzmann Equation explaining the notations. If the steady state distribution function f is a function of only the integrals of the motion, explain why it will satisfy the CBE? **(b)** Starting with the spherically symmetric isochrone potential, derive the velocity and density profile. **(c)** Show that, at small r, the potential is equivalent to that of a homogeneous sphere. **(d)** Show that the density falls as r^{-4} at large r. **2 + 4 + 2 + 2**

Q.5 **(a)** Consider typical galaxy parameter of almost constant circular velocity of 220 km s^{-1}, and $d(\Omega - \kappa/2)/dR$ = 0.4 km s^{-1} kpc^{-2} at R = 10 kpc. Starting with a straight radial arm at t = 0, what will be the spiral pitch angle at t = 10 Gyr for material arm and density wave scenario? **(b)** Define velocity ellipsoid, and write down the Jeans equation clearly explaining the notation and symbols. **(c)** Consider typical galaxy with radius 10 kpc and velocity dispersion 300 km s^{-1}, and typical cluster containing 100 galaxies within radius 1 Mpc shows velocity dispersion of 1000 km s^{-1}. Under suitable approximation, estimate the ratio of the total dynamical mass of all the galaxies in the cluster to the total dynamical mass of the cluster. **(d)** What is the local standard of rest? **4 + 3 + 2 + 1**