BSc/MSci Mid-Term Test

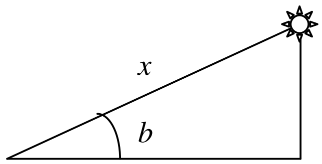
Physics of Galaxies

Time Allowed: 50 minutes

Date: 16 November, 2011, Time: 12:05 to 12:55

Candidates should answer ALL questions. An indicative marking-scheme is shown in square brackets [ ] after each (part of) a question. Total marks available 40.

1) Explain with an aid of a sketch why and how stars and gas execute *epicyclic* motion in spiral galaxies **[3 marks]**. Explain physical meaning of *Lindblad resonances* **[3 marks]**.



2) Show that the number of magnitudes by which an extragalactic source at galactic latitude angle b is dimmed for an observer in the mid-plane is given by

$$m - m_0 = \frac{1.25}{\ln(10)} \frac{kh}{\sin b} \qquad (2.1),$$

where k is the extinction per unit length due to galactic dust and one can model the galaxy as a cylinder of height h and a very large radius. Note that the flux decreases (due to the light extinction) by a factor $\exp(-kx)$ over a distance x i.e. $F=F_o \exp(-kx)$ and that apparent magnitude is related to flux by $m - m_O = -2.5 \log (F/F_o)$, where symbols with subscript "o" refer to values without the extinction) **[3 marks]**. Why do you think Eq.(2.1) is no longer applicable to the sources near the galactic mid plane? **[1 mark].**

3) Explain why the spiral arms predominantly form in disk galaxies with *trailing* spiral density waves. Your answer should include discussion of (i) phase speed of the wave **[2 marks]**; (ii) the role of shock formation **[2 marks]**; (iii) Jeans mass **[2 marks]**; (iv) lifetimes of OB stars compared to the gas circulation period in the Galaxy **[2 marks]**.

4) Define *surface brightness* of a galaxy, I, in terms of the flux density, dF, and solid angle $d\Omega$ **[2 marks]**. Define *magnitude per solid angle*, μ, of the same galaxy in terms of I and I_0. Here I_0 is surface brightness corresponding to the flux density F_0 emitted in a standard solid angle Ω_0 **[2 marks]**.

5) Using spectroscopic methods, the observed, normalised, mass-luminosity ratios, M/L, are ≈20-40 for elliptical galaxies and ≈10 for spiral galaxies. The same observed using photometric methods yields M/L≈1. Explain why there is such a large difference of the observational results produced by the two methods **[2 marks].**

6) You are given the dispersion relation for self-gravitating gas with non-zero pressure, $\omega^2 = u^2 k^2 - 4\pi G\rho$, where ω is the angular frequency, k is the wave-number, u is the sound speed and ρ is unperturbed density. Derive *Jeans length*, $\lambda_J = 2\pi / k_J = \left(\pi u^2 / G\rho\right)^{1/2}$ **[3 marks]** and *Jeans mass*, $M_J = \frac{\pi^{5/2}}{48} \frac{u^3}{G^{3/2}} \frac{1}{\sqrt{\rho}}$ **[4 marks].** Use the above dispersion relation with the thermal pressure support effects neglected to derive *the free fall time*, $\tau_{ff} = 1/\sqrt{4\pi G\rho}$ **[3 marks]**.

7) Derive the expression for e, the *ellipticity* of a thick galactic disk, $e = 1 - \cos\theta - (c/a)\sin\theta$ **[4 marks]**. Here a is the disk radius. Disk is $2c$ thick and the angle between disk normal and the line of sight is θ. [Hint: $e = 1 - thickness / width$]. Provide an explanation why the flattest elliptical galaxies, E7, cannot be disk galaxies at an inclination, by calculating c/a value for the maximal, edge-on, inclination (i.e. $\theta=\pi/2$) and comparing it to the typical observed values for disk galaxies **[2 marks]**.

[Total marks available 40] **End of Mid-Term Test** **Dr. D. Tsiklauri**