640-177: Stars and Galaxies

Problem Sheet 1: Our galaxy, optical and infra-red telescopes

1. An astronomer, Prof Henrietta Gazealot, observes two variable stars in a distant star cluster and calls them V1 and V2. The first, V1, cycles in brightness twice per day, while its slower cousin cycles every 10 days. Prof Gazealot also measures the apparent brightness of these stars, at 2.3 × 10⁻¹³ W m⁻² and 3.5 × 10⁻¹² W m⁻² respectively.

(a) What kind of variable stars are these?

(b) Based on the graph given in your notes, estimate:
   i. the luminosities of V1 and V2
   ii. the uncertainties in these luminosities
   iii. the distances to each, in parsecs

(c) Are these stars in our galaxy?

(d) Are these stars close to each other?

2. Astronomer Dr Grollo would like to build a new telescope. He applies for money to build the world’s biggest, with a single 12 m diameter mirror, to be built in downtown Melbourne. Give three reasons why his grant application is unlikely to succeed.

3. Dr Grollo’s telescope was to have a Cassegrain configuration, with a 0.5 m secondary mirror. What fraction of the light is wasted due to the obstruction by this secondary mirror?

4. On an Earth-like planet somewhere far away, bug-eyed aliens have eyes which are large enough that their resolution is as good as the seeing allows, that is, about 1 arcsec. What is the diameter of the lens in their eyes, assuming they see the same visible wavelengths that we do? If their eyes are the same size as ours, what wavelength must they see?

5. If intelligent life can only exist on rocky planets (like the Earth), and if rocky planets are made of heavy elements (like carbon and silicon), where is the best place to look for alien civilisations in our galaxy; the disk or the halo?

6. An intrepid rocket pilot is shooting through space when she notices a cloud of hydrogen directly ahead. Without slowing, she aims her pocket radio telescope at it, and discovers strong emission at a wavelength of 22 cm. Is she in any danger of being hit by this cloud of gas? Explain your reasoning.

7. The centre of our galaxy is surrounded by a ring of gas, with a radius of 1 parsec. If this ring is rotating at a speed of 80 km s⁻¹, what mass is at the center of the galaxy (in units of solar mass)?

8. In a galaxy far far away, the stars far from the centre orbit much more slowly than those near the center. Where is most of the mass in this galaxy?

9. Our intrepid rocket pilot also keeps a careful eye out for brown dwarfs, comets and planets, using her pocket infrared detector. If she detects such objects at temperatures below 77 K, what wavelengths is her detector sensitive to?

\[ 7 + 2 + 1 + 3 + 1 + 3 + 3 + 3 + 2 = 25 \text{ marks} \]