

Physics of Galaxies Exercises Class 1

1. A model of the Galaxy by Kapteyn was much smaller (10 kpc) and thicker, relative to its diameter, than currently accepted models (50 kpc); while Shapley's model was much larger (100 kpc) and thinner. Describe the reasons for the above two discrepancies. In this context, what was the significance of measuring distance to the Andromeda galaxy for the first time by E. Hubble? **[5 marks]**

2. If electromagnetic wave propagates radially away from the observer, Doppler shift reduces its frequency (and amplitude) according to $f = f_0 \sqrt{\frac{1-v/c}{1+v/c}}$. Show that for non-relativistic

speeds the red shift $z = \frac{\lambda - \lambda_0}{\lambda_0} \approx \frac{v}{c}$. **[5 marks]**

3. If θ is the angle between the direction of relative motion and the direction of emission in the observer's frame (zero angle is directly away from the observer), the full form for the relativistic Doppler effect is: $1 + z = \frac{1 + v \cos \theta / c}{\sqrt{1 - v^2 / c^2}}$. Show that for the special case when the

light is approaching at right angles ($\theta = 90^\circ$) to the direction of relative motion in the observer's frame, also known as the *transverse redshift*, the motion speed can be expressed as

$\frac{v}{c} = \sqrt{1 - \frac{1}{(1+z)^2}}$. **[5 marks]**. Calculate speed of a galaxy moving purely transverse to the

line of sight with $z=9$. **[2 marks]**. Given that all galaxies recede from us in nearly radial direction, what might cause the transverse motion of such galaxy? **[3 marks]**.

20 marks in total