

ASTRONOMY 8400 – Spring 2024  
Homework Set 1, Due 2/6/24 at 10:30 AM

1. a) From Special Relativity:

$$\text{Given: } 1+z = \frac{\lambda_{obs}}{\lambda_{lab}} = \sqrt{\frac{1+\beta}{1-\beta}}, \text{ where } \beta = \frac{v_r}{c}$$

$$\text{Show that : } \beta = \frac{(1+z)^2 - 1}{(1+z)^2 + 1}$$

b) At what redshifts does the approximation  $\beta = z$  differ from the relativistic value by 1%? At what redshifts do they differ by 10%?

c) Given the peculiar velocities of galaxies can often be as large as  $600 \text{ km s}^{-1}$ , at what redshifts does the equation  $v = H_0 d$  give a distance that could be in error by as much as 10%?

2. Look up NGC 4151 on the NED web site. Using the information you find there, list or determine its following properties. For each, **list how the property was determined and the reference, when appropriate.**

- a) Right Ascension and Declination (J2000)
- b) Redshift
- c) Distance: from redshift and from non-redshift techniques
- d) Host galaxy and Seyfert types
- e) Scale (arcsec/kpc): calculate from redshift and compare to NED values
- f) NED Major and minor axes of galactic disk (in arcmin and kpc)
- g) Inclination of host galaxy disk (zero degrees is face-on)
- h) Galactic (Milky Way) reddening ( $E_{B-V}$ )

3. Given a standard AGN torus with inner edges defined by polar angle  $\theta \geq \theta_{\min}$  with respect to its axis and an observed ratio  $x = \# \text{ Seyfert } 2s / \# \text{ Seyfert } 1s$ , derive the equation for  $\theta_{\min}$  as a function of  $x$ . What is  $\theta$  for  $x = 2$  and  $x = 3$ ?