ASTR368
HW#5
March 1, 2024
Due March 8, 2024
2 points each part unless otherwise stated

1) The distance ladder! In reverse!
a) Using Hubble's Law and an appropriate value for H_0, derive the distance to the Coma cluster. Assume the recessional velocity is 7,000 $\mathrm{km\,s^{-1}}$ and use both the relativistic and non-relativistic formulae.
b) What is the redshift of the Coma cluster?
c) By what amount would the Hα line be shifted in nm?
d) If the typical absolute visual magnitude of a Type 1a supernova is $M_V = -19.3$, at the distance calculated in a), what is the apparent magnitude of a Type 1a supernova in Coma? Assume no extinction.
e) If you found a Cepheid in one of the Coma cluster galaxies with a period of two weeks, what would its apparent visual magnitude be?
f) What would the expected parallax of a galaxy in Coma be? Compare that with the Hubble angular resolution.

2) Cluster masses
a) (4 pt) Derive the relationship for the gravitational potential of a cluster assuming it is spherical. Start with the change in potential with radius:

$$dU = -G\frac{M_r dm}{r}\,. \tag{1}$$

(This was the equation I blanked on in class!). Then you'll need an expression for dm and to integrate and to assume that the density is constant.
b) Use the Virial Theorem to derive the mass of the cluster in terms of σ_r and R.
c) Compute the mass of the Coma cluster assuming $\sigma_r = 1{,}000$ $\mathrm{km\,s^{-1}}$ and its radius is 3 Mpc.
d) Compare the crossing time with the Hubble time for the Coma cluster. Assume the same velocity dispersion of 1,000 $\mathrm{km\,s^{-1}}$ and radius of 3 Mpc.
e) Based on your answer to d), is the Coma cluster likely to be virialized? Why or why not?