ASTRONOMY 8400 – SPRING 2024
Homework Set 4, Due 4/18/24 at 10:30 AM

1. Suppose that you have a thin rotating disk at an inclination of 60º from your line of sight with constant surface density (mass per area).

a) What is the equation for the enclosed mass M(R) as a function of R and the true rotational velocity as a function of R?
b) What is the equation for radial (line of sight) velocity as a function of R, azimuthal angle Φ, and inclination angle i?
c) Make a plot showing isovelocity contours (spider diagram) for the inclined disk

2. Given a central stellar velocity dispersion of $\sigma = 200$ km s^{-1} for a galaxy:

a) What is the minimum supermassive black hole mass detectable at a distance of 10 Mpc using HST?
b) How about for a ground-based telescope with an angular resolution of 1"?
c) What are the lower limits to the bulge luminosities for cases a) and b)? What kind of galaxies would you be looking at?
d) Based on recent observational results, what is the most likely mass of the supermassive black hole for this velocity dispersion?

3. Suppose you have the following (normalized and very simplified) Ca II λ8542 absorption-line profiles for a nearby K giant star (at v_r=0) and a galaxy:

λ	8540	8541	8542	8543	8544	8545	8546	8547	8548	8549	8550
Star	1.0	0.7	0.4	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Galaxy	1.0	1.0	1.0	1.0	0.8	0.6	0.4	0.6	0.8	1.0	1.0

a) Compute a cross-correlation function (CCF) for the star and galaxy – show the graph.
b) Compute an auto-correlation function (ACF) for the star and galaxy – show the graph.
c) From the CCF, what is the radial velocity centroid (v_r) of the galaxy? How does this compare with a direct measurement?
d) What is the FWHM and velocity dispersion for the Ca II line in the galaxy? Correct for the instrumental broadening exhibited by the stellar line assuming that the profiles are Gaussians (remember that the widths of Gaussians add in quadrature).