Physic 325:Astrophysics. HW 3 Due Wed Nov 8.

In general, I expect you to work problems out from first principles—the goal is to develop the skills of applying your basic physics to astrophysical situations, not to apply random formulas. I expect you to be clear and justify any assumptions you make in working out these problems. I expect you to show all steps. If you look up any quantities, you must provide references.

1. To reach optical instruments on the surface of the earth, starlight must pass through the earth's atmosphere. Because of scattering, not all the light reaches the surface of the earth. This process is called atmospheric extinction.

a) If just the air is responsible for the scattering, what type of scattering is it (from among the types we've discussed/are discussed in the text)? Justify your answer quantitatively for λ=530 nm.

b) The amount of atmospheric extinction is different for an object seen overhead compared to one seen at the horizon. Explain why.

c) The text points out that at λ=530 nm, the nitrogen in our atmosphere has a Rayleigh cross section of σ_s= 5.1×10^{-31} m^2 . Use this to determine the amount of atmospheric extinction for light of this wavelength that comes from overhead compared to coming from the horizon. Quantify this by the fraction of radiation lost to the radiation incident. To do this you will need to use that α_v= n(x) σ_s where n(x) is the number density of the scattering nitrogen molecules as a function of distance through the atmosphere. You will also need a model for n(x). Consider 2 cases: 1) earth's atmosphere is uniform in density; 2) Earth's atmospheric density falls with distance above the earth as $n=n_0e^{-x/l}$ where l=8 km.

2. Locate a value for the earth's orbital eccentricity and semi-major axis (cite sources).

a) By how many meters closer is the earth to the sun at its closest compared to its farthest?

b) The earth moves faster in its orbit at perihelion compared to aphelion.

i) Why?

ii) By how much?

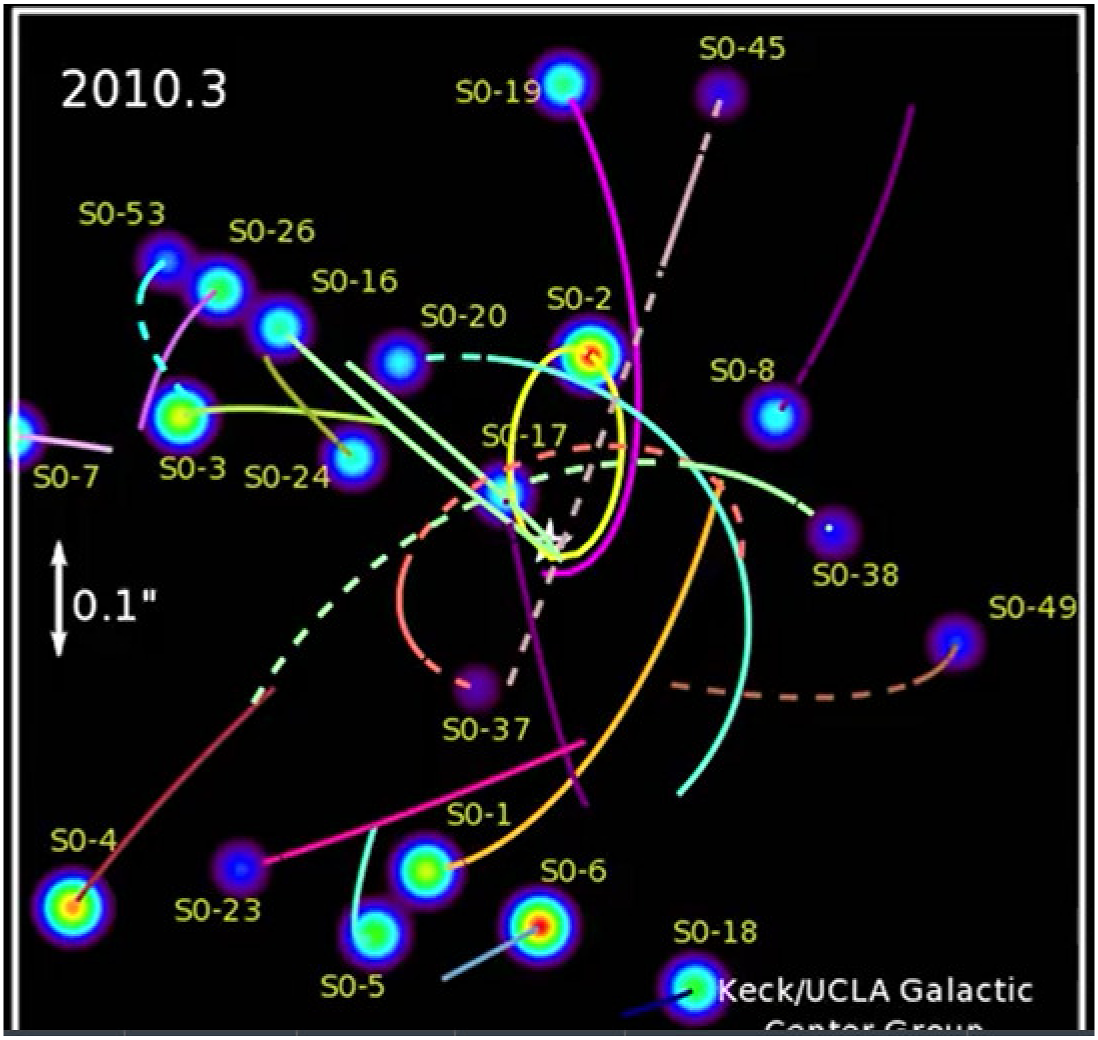
3. Using the masses of the sun and the orbital parameters you found for #2, determine the semi major axis of the ellipse the **sun** follows around the common earth-sun center of mass (neglect all other objects in the universe). Compare the result to the radius of the sun and interpret.

4.a) Noting that Kepler's 3rd law only depends on the mass of the central object in an orbit if that objects mass is >> the mass of the orbiting objects, show that if we observe the period of such orbiters in years and know the size of the orbit in AU, we can determine the mass of the central object in solar masses.

b) From this youtube video (https://www.youtube.com/watch?v=EvuV3GdVaY4) of stars orbiting the black hole at the center of the Milky way

i) pick one star and determine its period (note the dates of the observations at the top left)

ii) for that same star, find the size of its orbit. Note there is an angle size marker so you will have to use the distance to the center of the Milky Way and find an appropriate **linear** scale. You might find a ruler and the still from the last frame below helpful in that.



ii) use Kepler's 3rd law to determine the mass

iii) is the mass you found an upper limit or lower limit on the true mass? To answer this consider the effect of a possible tilt of the star's orbit—does that make the true semi-major axis larger or smaller than what you calculated in above?