Astronomy 142 — Recitation #11

Prof. Douglass

April 12, 2024

Formulas to remember

Eddington luminosity

$$L < L_E = \frac{3GMm_p m_e^2 c^5}{2e^4} \qquad\qquad M_E > \frac{2e^4 L}{3Gm_p m_e^2 c^5} \tag{1}$$

Superluminal motion in AGNs

$$v_{\perp,\text{apparent}} = \frac{v\sin\theta}{1-\frac{v}{c}\cos\theta} \qquad\qquad (v_{\perp,\text{apparent}})_{\max} = \frac{v}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = \gamma v \tag{2}$$

Atmospheric extinction correction

$$\begin{aligned} f &= f_0 e^{-\tau} = f_0 e^{-\tau_0 \sec ZA} \\ &\cong f_0(1-\tau_0 \sec ZA) = f_0 - f_0\tau_0 \sec ZA \end{aligned}$$

Workshop problems

Remember! The workshop problems that you will do in groups in Recitation are a crucial part of the process of building up your command of the concepts important in ASTR 142 and subsequent courses. Do not, therefore, do your work on scratch paper and discard it. Better for each of you to keep your own account of each problem in some sort of bound notebook.

1. Consider the geometry described in class for superluminal motion. A clump within a quasar jet moves at speed v along a straight trajectory at an angle θ with respect to an Earth-bound observer's line of sight. Said observer records the blob's position on the sky at two times, $t = 0$ and t_0.
   (a) Derive the expression for the apparent speed $v_{\perp,\text{apparent}}$ of this blob in the plane of the sky, in terms of v and θ.
   (b) From the resulting expression, show that there is a maximum value of $v_{\perp,\text{apparent}}$ for a given jet speed v.

2. Return to the galaxy that we studied in Question 5 on Problem Set 7. Suppose that the dark matter halo follows its given functional form out to a radius R_1 that is equal to ten times the scale radius R_0, after which it drops more rapidly and becomes negligible. Integrate the expressions for mass and light per unit area from the center out to $R = R_1 = 10R_0$, use the expression derived for $\rho_0/\mathcal{L}(0)$, and obtain a value for M/L that applies to the entire galaxy. What is this value in solar units?

Intro to Python (A feature *exclusive* of ASTR 142 recitations.)

3. Two stars — call them A and B — with declinations $28.0°$ and $20.0°$ respectively, are observed every half hour from an observatory with latitude $43.0°$. The signals in "data numbers" and the zenith angles of the stars at each time are given in the data file `StarsAB.txt` on the course website. Star A is a well-known, well-behaved star with time-independent magnitude 8.0. The properties of star B are unknown and for you to figure out.

   (a) The atmosphere can be assumed to be a plane-parallel layer of gas, set between our location on Earth's surface and outer space. Like all gases, our atmosphere is very good at absorbing and/or scattering light. Therefore, any object that we observe will be fainter than what would be measured if we were above the atmosphere. The fraction of the light that is "removed" from the observed signal due to the atmosphere is known as the atmospheric extinction.

   Determine the minimum value of atmospheric extinction, τ_0, for the provided data, assuming that it was constant throughout the night. Then, determine the signal of star A corrected for atmospheric extinction (that is, the signal of star A if there was no atmosphere).

   (b) Using the atmospheric extinction as a function of ZA determined for star A, correct the observations for star B for atmospheric extinction. Then, determine the magnitude of each star as seen in each observation, and plot the magnitudes as a function of time throughout the night. What have you learned about star B?