ASTR 300B – Fall 2024

<u>Due: Tue. Sept. 24</u>

11. Consider a spherical source with radius R and a constant temperature T emits in ***thermal equilibrium*** at a distance D where D >> R. The source has a constant emissivity coefficient of j_ν and a negligible background radiation field. Your answers should only depend on numbers, $B_\nu(T)$ (which you can leave as that - don't have to write it out), j_ν, R, and/or D . HINT: Prior homeworks may be helpful.

(a) Calculate the flux density observed at the Earth from the entire source in the **optically thick** limit.
(b) Calculate the flux density observed at the Earth from the entire source in the **optically thin** limit.

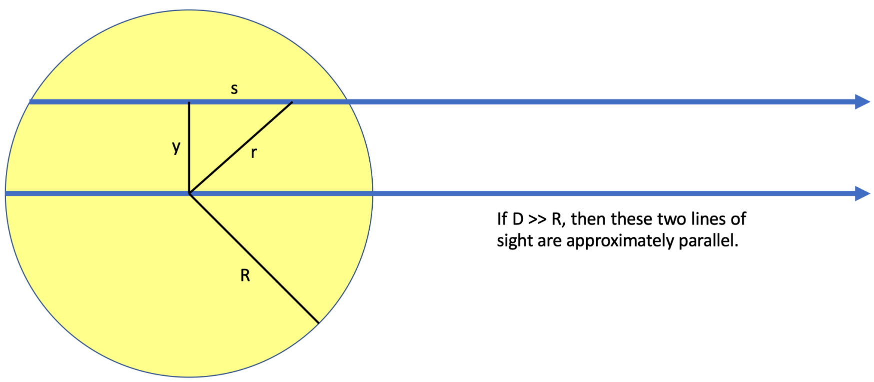

Fig. 1: The observer is located to the right and very far away. If D >> R, then a line-of-sight at angle θ (the upper arrow) and a line-of-sight through the center of the source (the bottom arrow) are approximately parallel to each other. The variable y is called the "impact parameter" and it is the perpendicular distance from the center of the source to the line-of-sight at angle θ.

12. Calculate the optical depth due to rayleigh scattering of N_2 in the Earth's atmosphere at 532 nm for an observer staring at zenith. Assume that the distribution of N_2 is exponential, $n(h) = n_0 \exp(-h/h_0)$, with scale height of h_0 = 9 km. The air density at sea level is 2.7×10^{19} molecules/cm^3 and N_2 is 78% by number. Quote your answer to 2 decimal places.

Gas	Measured $\sigma_{\bar{\nu}}$ $/10^{-27}$ cm^2
Ar	4.45 (0.3)
N_2	5.10 (0.24)
CO	6.19 (0.4)
CO_2	12.4 (0.8)

Table 1: Scattering cross-sections measured at 18788.4 cm^{-1} (take inverse to get ~532 nm) from Sneep & Ubachs 2005, Journal of Quantitative Spectroscopy and Radiative Transfer.