UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Astrophysics I (ASTR 691) — Prof. Crossfield — Fall 2026

In-Class Problems 7

You may use your OoMA Sheet, your handwritten notes, and a scientific or graphing calculator – and you may work in a group. As always, be sure to: show your work, circle or highlight your final answer, list units, use the appropriate number of significant figures, and write your name.

1. **Real Radiative Transfer (Absorption Only) [20 pts]**. Assume that a molecule of Ozone in Earth's atmosphere has a cross-section of:

λ [nm]	σ_λ [cm^2]
210	1×10^{-18}
240	7×10^{-18}
258	10×10^{-18}
280	4×10^{-18}
285	2×10^{-18}

   (a) Sketch the ozone cross-section across the full width of this absorption band. (For this and the other plots you will make below, use a wavelength range no narrower than 200–300 nm). [3 pts]

   (b) Ozone is mainly found in the Earth's stratosphere, where a (very!) rough average for the number density of ozone particles is $n \sim 3 \times 10^{11}$ cm^{-3}. Calculate and plot the absorption coefficient α_λ for ozone at these wavelengths. [4 pts]

   (c) Earth's ozone is mainly concentrated at altitudes from 15–35 km above the Earth's surface. Assume that n is constant with altitude in that range, and then calculate and plot the optical depth τ_λ of Ozone in Earth's ozone layer (at these wavelengths). [4 pts]

   (d) Considering only this absorption band (and no other atmospheric absorption features), (i) calculate and plot what fraction of incident Sunlight reaches the surface of the Earth across this ozone absorption band, i.e. as a function of wavelength. What fraction of light reaches the Earth's surface (ii) in the central 'core' of this absorption band, at 258 nm, and (iii) far in the 'wings' of the band, say at 200 nm or 300 nm? [5 pts]

   (e) Fig. 1 shows the transmission of light through Earth's atmosphere across a much wider range of wavelengths. Explain how one might extend the analysis you just completed (i.e., one absorption band of one molecule over a narrow wavelength range) to generate a more complete transmission model such as this. [4 pts]

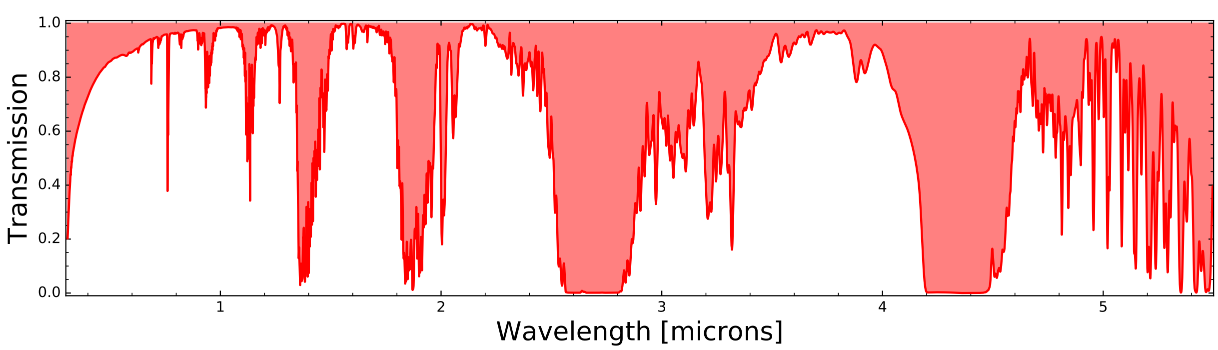

Figure 1: Transmission of the Earth's atmosphere vs. wavelength over optical and near-infrared wavelengths. Shaded wavelengths are more opaque, while white wavelengths are more transparent.