



1. Let this figure represent the location of the Sun in the plane of the Milky Way galaxy (Our home!). It is essentially at the mid-plane of the disk. Suppose that the density of interstellar dust is uniform along the direction of the plane of the galaxy, but that its vertical density is given approximately by

$$\rho = \rho_0 e^{-\left(\frac{z}{0.15}\right)^2}$$

where z is the distance from the plane of our galaxy in kpc. If the net extinction perpendicular to the galactic plane is 0.4 magnitudes (i.e. integrated from the mid-plane to infinity), find the extinction to an object in the galactic center, 8 kpc away (and where $z=0$), and the ratio of the number of photons before and after the extinction. (6 points) HINTS:

$$d\tau_\lambda \equiv \overbrace{a_\lambda}^{cm^2} \underbrace{n}_{cm^{-3}} dx = \overbrace{\kappa}^{cm^2 g^{-1}} \underbrace{\rho}_{g cm^{-3}} dx$$

$$\tau_{center} = \int_{x=0}^{x=8kpc} \kappa \rho dx = 1.086 \int_{x=0}^{x=8kpc} \kappa \rho_0 e^{-\left(\frac{0}{0.15}\right)^2} dx$$

$$\tau_{vertical} = ???$$

$$A_\lambda (mag) \approx 1.086 \tau_\lambda$$

$$\text{and } I_\lambda = I_{\lambda,0} e^{-\tau_\lambda}$$

2. Go to the ADS web page at http://adsabs.harvard.edu/abstract_service.html and get a copy of Bruce Draine's 1995 article entitled "Properties of Dust in Diffuse Clouds". Look at the extinction curves in Figure 1. Each curve has been "normalized" by a constant factor to place lines of sight with different amounts of dust on the same curve (so that only the differences in *shape* and not *total strength* are shown). Note the extinction has been normalized to 1 mag in the "I" photometric band, which has a wavelength of about 0.86 μm , while this has traditionally been done in the "V" band (0.55 μm).

Look at his Figures 2 and 3.

- a. What is the ratio of extinctions, in magnitudes, between the center of the 9.7 μm silicate band and the I band? (1 point)

- b. What is the ratio of extinctions in magnitudes between the 2175 \AA band and the I band? (1 point)

- c. Finally, using these two numbers, what is the ratio of extinctions in magnitudes between the 9.7 μm silicate band and the 2175 \AA band? (1 point)

- d. Now, suppose an astronomer wanted to measure the shape and strength of the 2175 \AA band to a star behind an interstellar cloud where $A(9.7 \mu\text{m}) = 0.3$ mag. What is the extinction going to be in the 2175 \AA (0.2175 μm) band in mags? What does this correspond to in terms of the ratio of obscured flux compared to unobscured flux? (2 points)

- e. There is almost NO individual line of sight where the entire extinction curve has been measured from 20 μm to 1200 \AA . Explain why. How might this affect our conclusions about the relative mixtures of grains we deduce for the interstellar medium? (2 points)

3. If interstellar grains are spherical with a size distribution $n(a)$ (so that $n(a)da$ is the number of particles/cm³ with radii between a and $a+da$), find the mass of particles/cm³ necessary to produce 1 mag/kpc of extinction at $\lambda=0.5 \mu\text{m}$. Assume that $Q=2\pi a/\lambda$ and that the mass density within individual grains is 2 g/cm^3 . (4 points)

4. Dust and Distance

a. The presence of interstellar extinction makes stars appear dimmer and appear more “distant” than they truly are. This is true for individual stars and for clusters of stars. Does dust affect the observed *angular size* of a star cluster (assuming the distribution of the dust is smooth)? That is, suppose there was a star cluster located 100 pc away. Would adding dust extinction affect its observed angular size? Assume that incompleteness in sampling is not a problem. (1 point)

b. If star clusters were all about the same physics size (diameter in pc), describe how could you estimate their relative distances. (1 point)

c. Would the distances determined geometrically give the same result as those determined photometrically (i.e., using stellar brightnesses $m = M - 5 + 5 \log d$)? Describe why or why not. (1 point)