A74, Dartmouth College
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A74 EXERCISES: Thermal radiation (1.5)

1. RR Lyrae is a prototype of a class of variable stars.

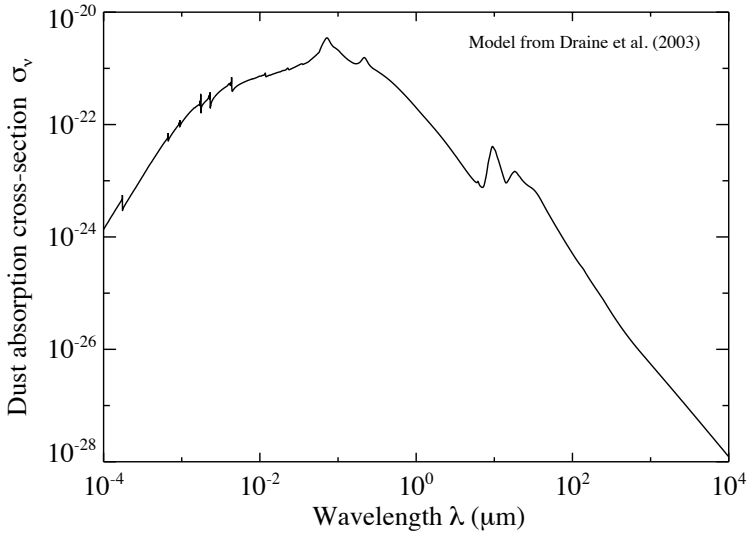
   a. Look up the star on SIMBAD `http://simbad.u-strasbg.fr/simbad/sim-fid` and get its parallax. What is the distance to the star in pc? Note that SIMBAD by default has the parallax in milliarcseconds, not arcseconds.

   b. The typical number density of hydrogen atoms in the interstellar medium in our Galaxy is $n_{\rm H} \sim 1$ cm^{-3}. (That's almost a perfect vacuum, but the mass adds up in the vastness of space!) Assuming that this density is constant across the Galaxy, what is the column density of hydrogen atoms ($N_{\rm H}$) toward RR Lyrae, in cm^{-2}?

   c. The *cross-section* for absorption from interstellar dust depends strongly on wavelength. If we think of dust and hydrogen gas as being equally mixed together in interstellar clouds, we can parameterize the absorption due to dust in terms of the effective absorption cross-section $\sigma_{\rm v}$ of each hydrogen atom. A plot of this quantity is shown below. Based on this plot, what is $\sigma_{\rm v}$ at around 500nm?

   d. What is the corresponding optical depth $\tau_{\rm v}$?

   e. What is the factor $(I_{\rm v}/I_{\rm v,0})$ by which the dust will attenuate the light toward RR Lyrae? (You don't need a calculator for this question).



Units on the y axis are cm^2 per H atom.

(Figure from B. Draine, Princeton University; data from: Draine, B.T. 2003a, ARA&A, 41, 241-289 Draine, B.T. 2003b, ApJ, 598, 1017-1025 Draine, B.T. 2003c, ApJ, 598, 1026-1037)

2. Mars is a near-blackbody, with a temperature $T_{\mathcal{O}} = 220K$. At closest approach to Earth, Mars has an angular diameter of 17.9 arcseconds.

   a. At what frequency does the blackbody spectrum of Mars peak? In what part of the electromagnetic spectrum does this fall? (You don't need a calculator for this question)

   b. Starting from Eq 1.3b, compute the flux of Mars at closest approach to Earth at an observing frequency of 15 GHz. You can use a calculator to calculate the final number but think about the simplifying assumptions you can make before getting there.

3. Consider the different definitions of temperature.

   a. Given the luminosity and radius of a star, which temperature can you measure?

   b. Given the magnitude of an object in two different filters (say, B and V), what temperature can you measure?

   c. Given the intensity at 10 GHz, what temperature can you measure?