1 Reflection from Planetary Atmospheres

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The wavelengths of the NaD and KI lines are 5890, 5896, 7665, and 7699. Their oscillator strengths are 0.64, 0.32, 1.35, and 0.68. Since the line is pressure broadened the profile is given by a Lorentzian

$$\phi(\nu) = \frac{\Gamma/4\pi^2}{(\nu - nu_0)^2 + (\Gamma/4\pi)^2} \tag{1}$$

where the width is the sum of the natural and pressure broadening $\Gamma = \Gamma_n + \Gamma_p$. We note that $\Gamma_p = 10^{11}$ Hz is two orders of magnitude larger than Γ_n so we can safely ignore the natural broadending.

Weighting the absorption cross-section by the oscillator strength and the abun- dance for each line, we obtain

$$\sigma_{\text{abs}} = \frac{\pi e^2}{m_e c} f \phi(\nu) \eta \tag{2}$$

where η is the fractional abundance of the atom responsible. The alkali atomic lines in question are resonance lines – i.e., the lower level is the ground state – and we can assume that essentially all of these atoms are in their ground state. Therefore η is given by the number abundance for solar metallicity.

Now we calculate the abundance-weighted absorption cross section in the resonances at line center: $1.32109 \times 10^{-18}, 6.60545 \times 10^{-19}, 1.71694 \times 10^{-19}$, and 8.60507×10^{-20} cm^2.

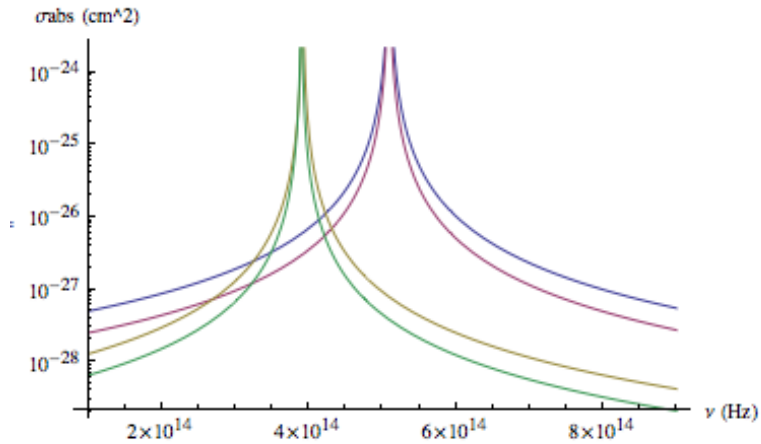

Figure 2: Absorption cross section, weighted by abundance, for the Na I and K I resonance transitions.

$$\sigma_{\mathrm{R}} = \sigma_{\mathrm{T}} \left(\frac{\nu}{\nu_0} \right)^4 . \tag{17}$$

where $\nu_0 = 2.5 \times 10^{15}$ is the frequency of the Lyman-α transition. We define the single scattering albedo as

$$\mathrm{a_{ss}} = \frac{\sigma_{\mathrm{R}}}{\sigma_{\mathrm{R}} + \sigma_{\mathrm{abs}}} \tag{18}$$

and plot it:

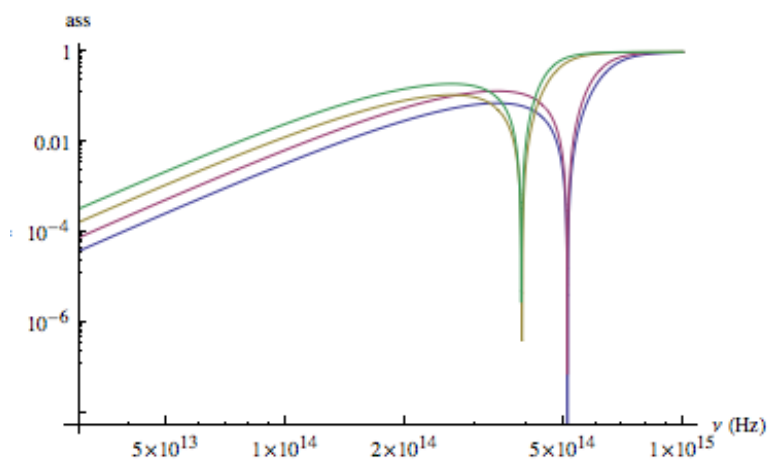

Figure 3: The single scattering albedo for the resonant transitions of Na I and K I. In general, the albedo rises with frequency. However, at the resonance frequencies, absorption dominates (this is the negative spike for each curve).