Why is the sky blue?

Really 3 questions:

1) Why is the sky blue, not black? cf. Apollo photos

2) " " , not red? (short λ instead of long)

3) " " , not violet? (why not shortest λ)

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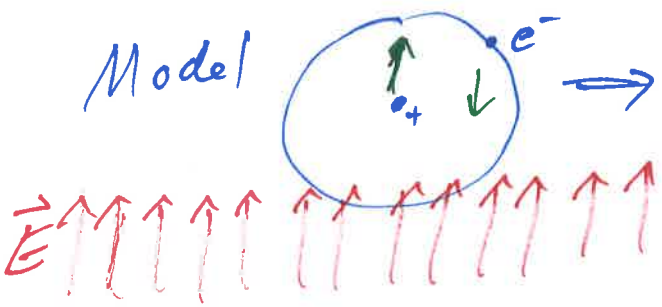
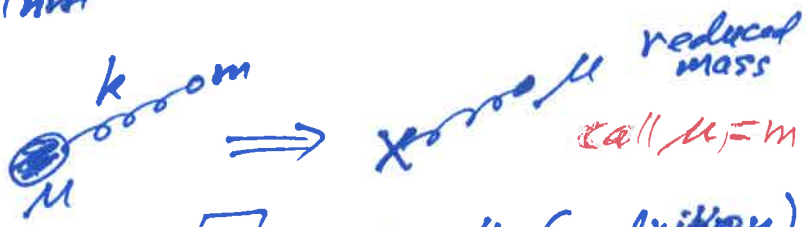
1) John William Strutt – 3rd Baron Rayleigh 1871–1899

For most gas molecules, magnetic moments are negligible compared to electric moments, electric dipole moment >> quadrupole, octupole,

Wavelength $\lambda \gg R$ size of molecule, electrically neutral.
400–700nm ⟨ 0.1nm

Model





$\omega_0 = \sqrt{\frac{k}{m}}$ naturally (undriven) ang. frequency of oscillation

$f = \frac{\omega}{2\pi}$

induced dipole moment

Newton's 2nd Law: $\sum F = ma$ – 2 forces – Hooke's spring / Electric force

$$m\frac{d^2z(t)}{dt^2} = -m\omega_0^2 z(t) - eE_0\sin(\omega t)$$

$m\omega_0^2$: k, natural; $eE_0\sin(\omega t)$: driving

2nd-order, linear (in z), non-homogeneous, ODE

driving (forcing) term

Resonance, no damping

$$z(t) = \frac{eE_0}{m(\omega^2-\omega_0^2)}\sin(\omega t)$$

electric dipole moment: $ze = p = \frac{e^2E_0}{m(\omega^2-\omega_0^2)}\sin(\omega t)$

↑ light charges contribute most e^- rather than nucleus

1) The electric dipoles oscillate and charges that accelerate radiate.. Gas molecules are randomly arranged. (not crystal).

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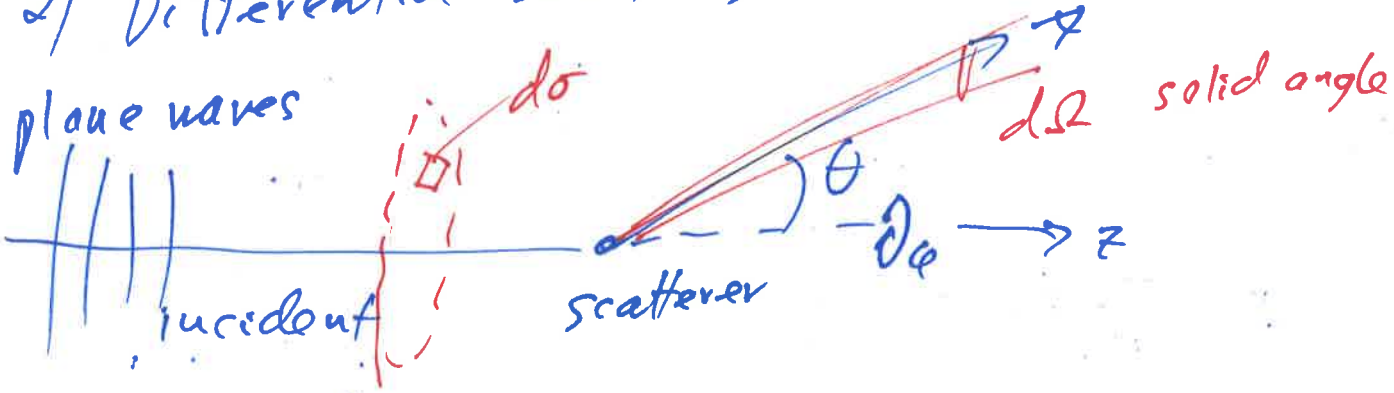
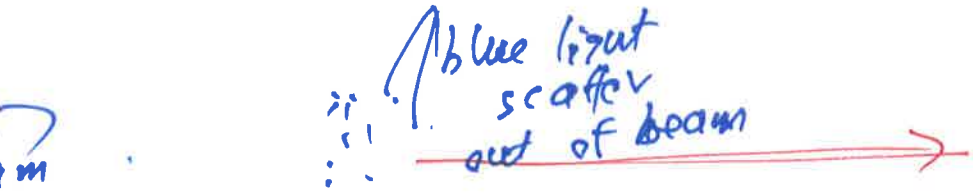
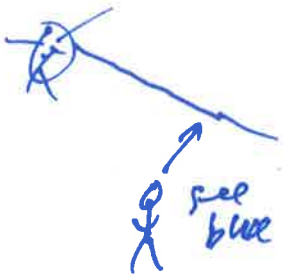
2) Differential scattering cross section







$\lambda_{blue} \sim 2$ red
λ 350nm 700nm

blue light is 2^4 more likely to be scattered

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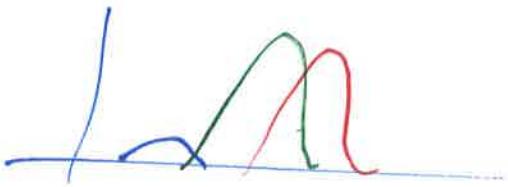
3) Why not violet?

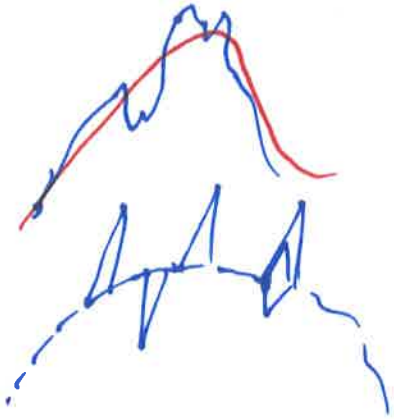
- Not a lot of violet in the solar spectrum no matter what variable (no plot, λ, ν.

Soffer + Lynch Planck curve

- Sensitivity of human eye, not sensitive in the violet



— Not really Planck



Absorption by gases in Earth's atmosphere.

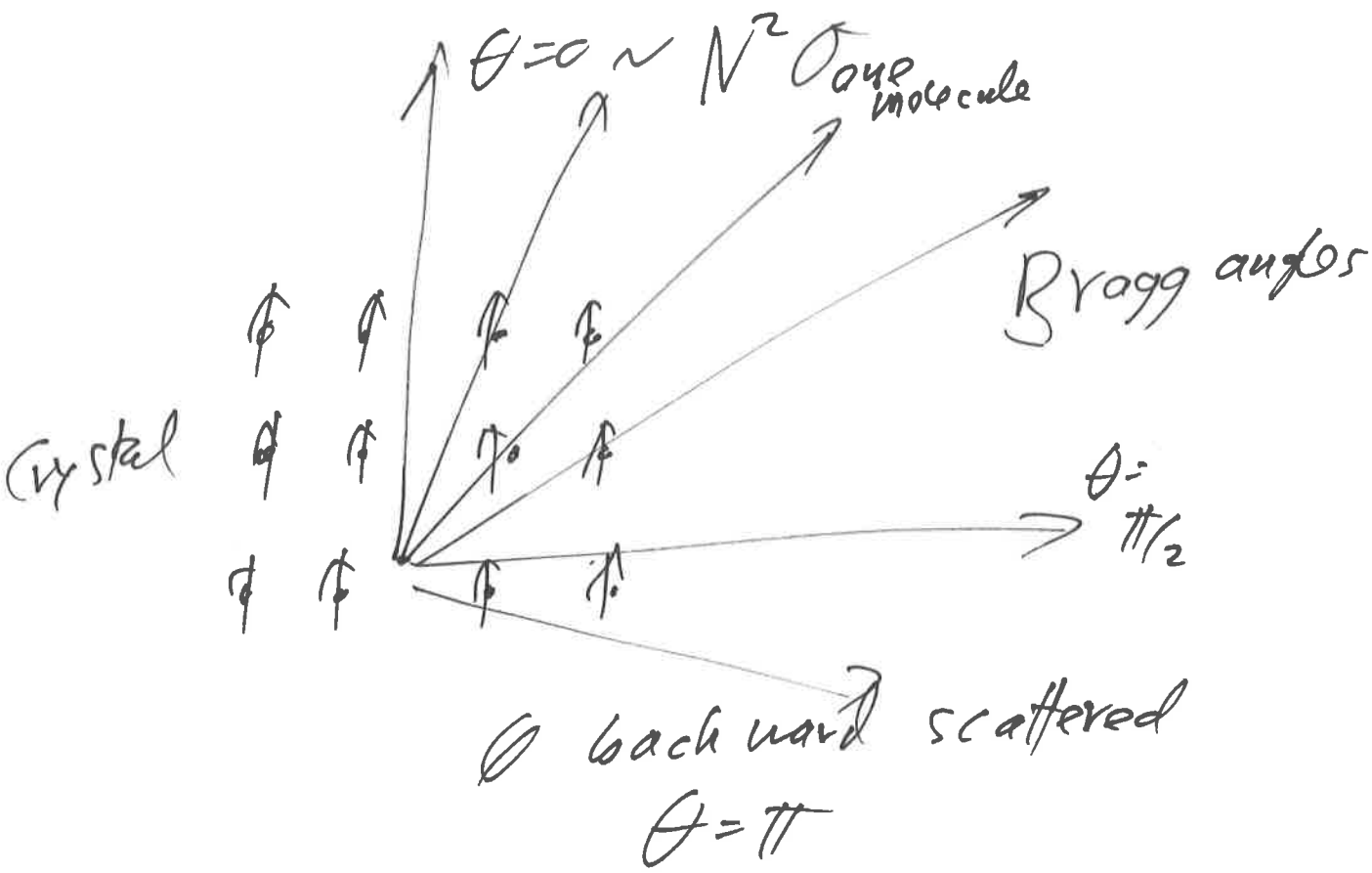
Line emission from Sun
Line absorption from Sun

- Mie Scattering - water drops, pollen, dust, smoke

$R \gg \lambda$

- Multiple scattering - clouds + snow white

- Glenn Smith Am J. Phys.



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gas

$\sigma_{\text{TOTAL}} = N \sigma_{\text{one molecule}}$