W6L2. 4.2 (GREY BODIES), 5.1, 5.2

A ~ 0 - 1

ex: planets, asteroids, comets, moons, dust, walls, surface of a human, a hound dog

the reflected light lets us see

the absorbed light heats up the object.

$\to$ radiates a Planck spectrum dependent on T

$$I_\lambda = I_{em,\lambda} + I_{refl,\lambda}$$

$I_{em,\lambda}$: emitted like a BB

$I_{refl,\lambda}$: we see

increase due to Rayleigh scattering

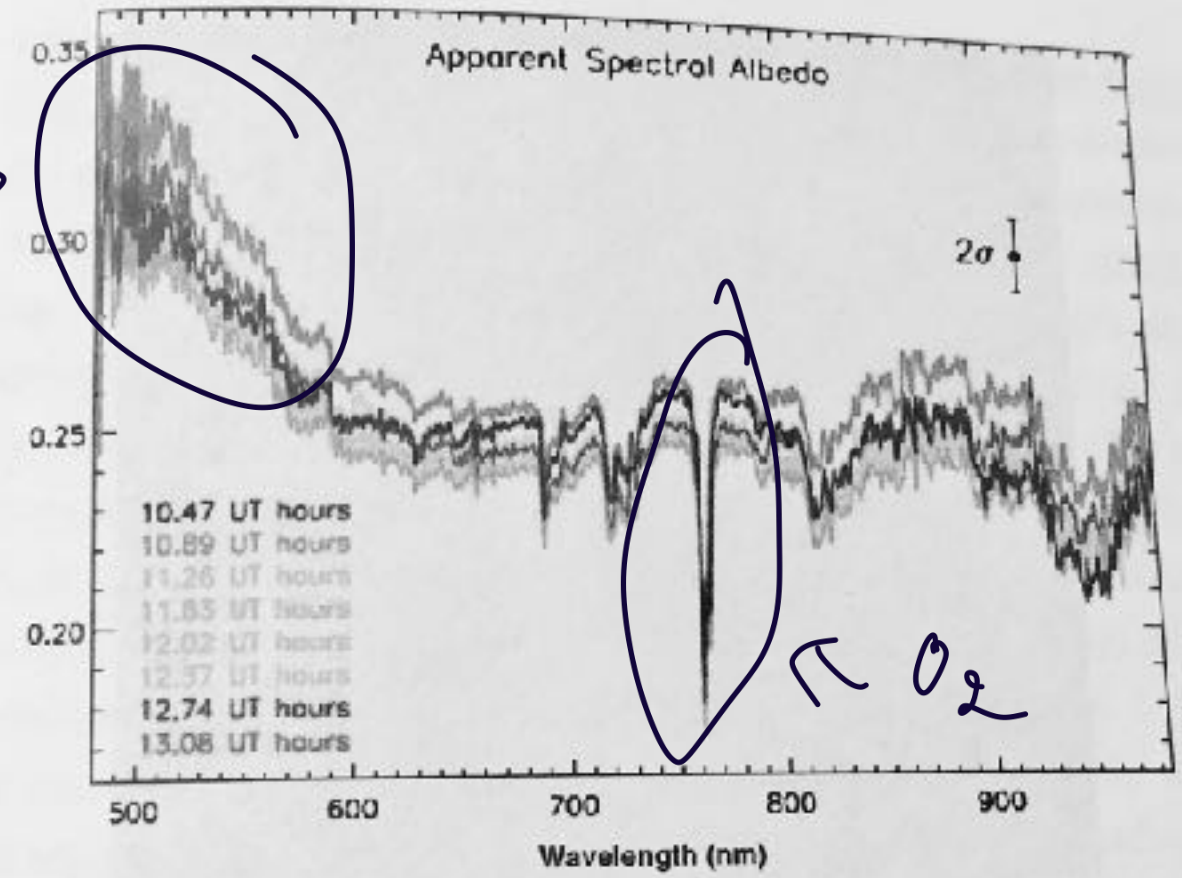

Figure 4.7. Plot of the Earth's albedo as a function of wavelength in the optical band, measured on 19 November 1993 at the times indicated. The albedo increases towards the blue (left) due to Rayleigh scattering (see Sect. 5.1.1.3) and a number of spectral features can be seen, including one at λ 760 nm due to O_2. These wavelength-dependent values are comparable to the Bond Albedo of $A = 0.306$ (Table G.4) which is the value applicable to all wavelengths. (Montañes-Rodriguez, P., *et al.*, 2005, ApJ, **629**, 1175. Reproduced by permission of the AAS)


Figure 4.8.
moon' phase
unique in the
This constrast
(The narrow
as coal
other icy
courtesy of
@SecureTeam10
SECURETEAM
“source”: Daily mail

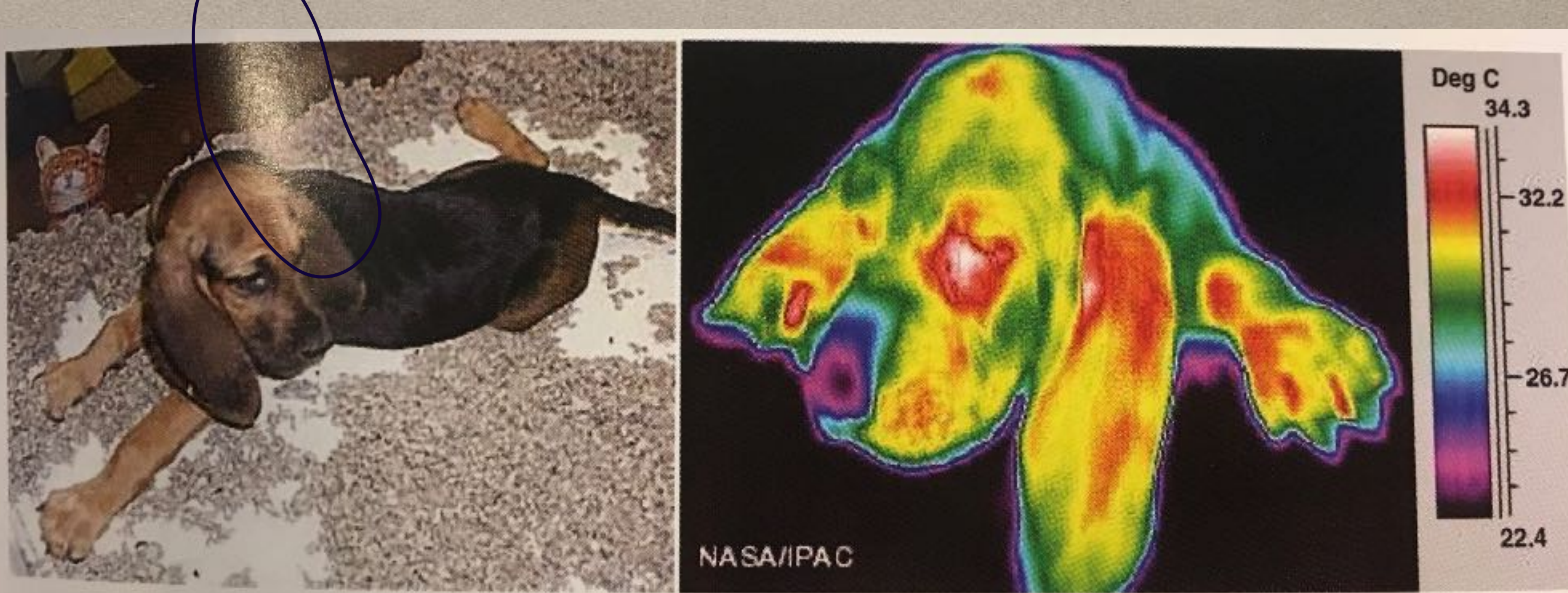

Figure 4.9

photons
⇒ see

photons absorbed + internal heat } are balanced by emission to get a balance
⇒ const Temp
emitted spectrum – Planck
peak in IR

1 - A of the light that falls in will be absorbed ⇒ heating ⇒ T_{eq}

Equilibrium temperature: rate of radiation from B.B (not reflection) balances the rate of the absorbing energy

$T_{equi} \neq T_{radiation\ field}$ (that it's inside of

but is the temp that corresponds the absorbed fraction of the incident radiation (assuming no other heating)

Peak of Planck

Solar system bodies also in IR

— dust in ISM IR or submm

gas giants: $T > T_{equi}$ ← from absorption

Earth radioactive decay, greenhouse effect

Ex 4.4 Determine T_{equi} of $\oplus$, cf to $T_{mean\,\oplus} = 14°C = 287K$

Earth absorbs over cross section $\pi R_\oplus^2$

(day/night variation $< 10K \ll T_{mean\,\oplus}$)

$L_{abs} = (1-A) \cdot \pi R_\oplus^2 \cdot f$ — flux of $\odot$ @ $\oplus$'s distance = Solar constant = $1367 W/m^2$

(A: albedo)

$$= \left[\begin{array}{l} L_\odot = 4\pi r^2 f \quad \text{eq } 1.9 \\ \quad\quad \uparrow \text{distance } \odot - \oplus \\ \Rightarrow f = \dfrac{L_\odot}{4\pi r^2} \end{array} \right] = \frac{(1-A) R_\oplus^2 L_\odot}{4 r^2}$$

$$L_{em} = [\text{eq } 4.13] = 4\pi R_\oplus^2 \sigma T^4$$

grey body emission from $\oplus$

T we want $= T_{equi}$

$$L_{abs} = L_{em} \Rightarrow T = \left(\frac{(1-A) L_\odot}{16\pi\sigma r^2} \right)^{1/4}$$

$$= T = \begin{bmatrix} A = 0.306 \; (G.4) \\ L_\odot = 3,845 \cdot 10^{33}\ \text{erg/s} \\ r = 1,496 \cdot 10^{13}\ \text{cm} \; (G3) \\ \sigma = 5.67 \cdot 10^{-5}\ \text{erg}/\text{cm}^2 K^4 \; (G.2) \end{bmatrix} = 254\,K = -19\,°C$$

$\bar{T} = +14\,°C$

$\Delta T = \sim 33\,°C$ due to the greenhouse effect

Peak of Planck (Wien's displacement law) in IR ($\lambda_{max} = 11\,\mu m$)

NB: eq 4.18 (for T) independent of $R_\oplus$

$\Rightarrow$ any planet @ r and A $\rightarrow$ same T_{equi}

4.2.2 - detection of extrasolar planets

CHAPTER 5: THE INTERACTION OF LIGHT WITH MATTER

matter:
- hot ionized gas
- cold clouds w/ complex molecules
- dust grains
- planets

Interaction ⇒ change in photon path and/or energy

⇒ 2 outcomes

- scattering
  - new photon with different energy
- absorption
  - photon lost
  - energy changes form to eg thermal

in either case, incoming beam is attenuated.

Scattering & abs effects

- opacity (gas)
- extinction (dust)

important entities

- crosssection σ that is presented to the photon by the particle
- number density of particles that the light hits

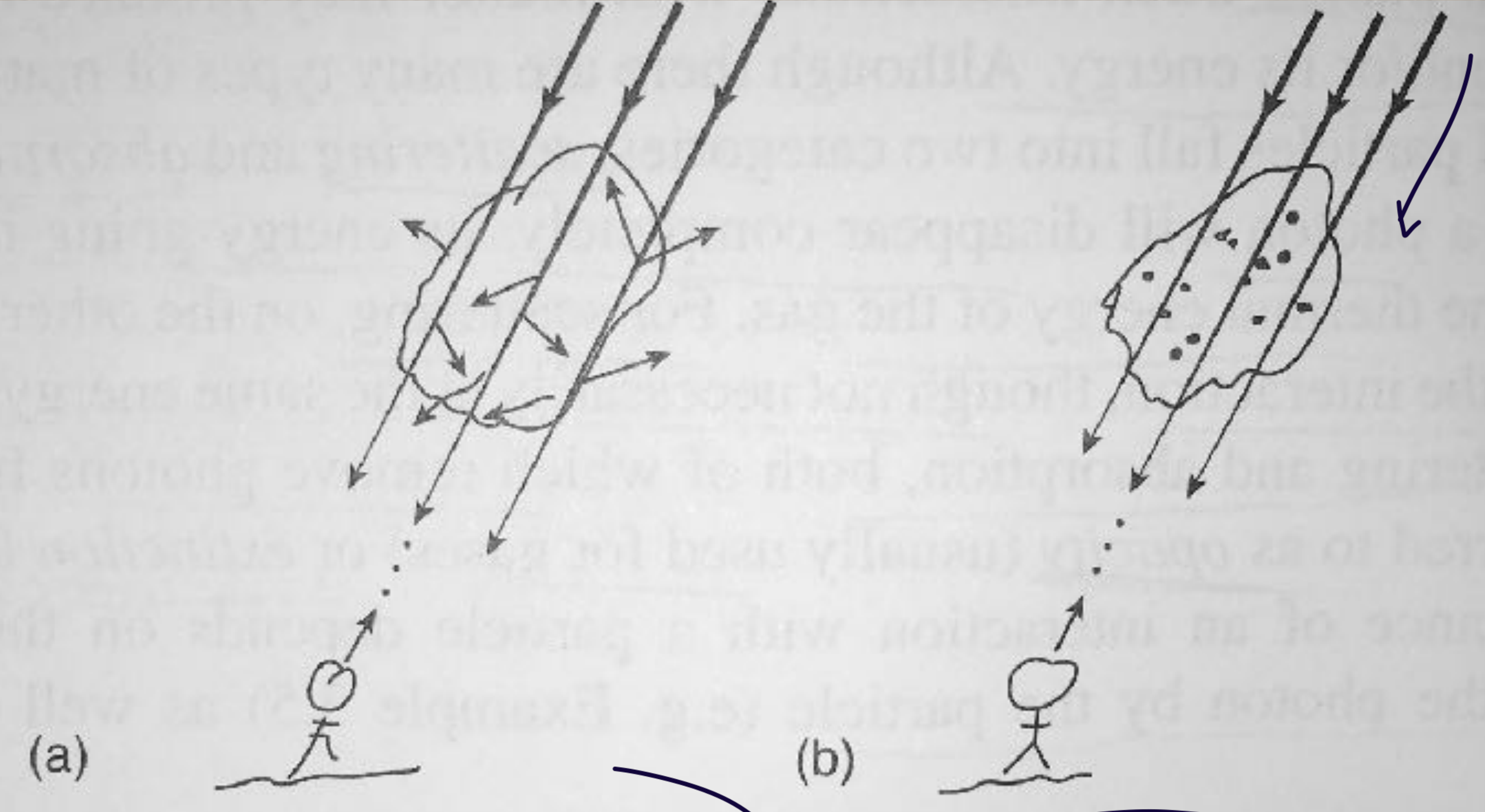

Figure 5.1. Illustration of (a) random scattering and (b) absorption along a line of sight. The observer is meant to be far from the source as well as the scattering medium in this diagram. Darker arrows convey a more intense signal.

reflection is a special case - back scattering.