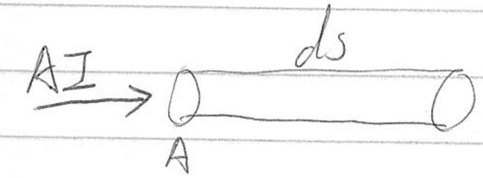
1. Radiative transfer
2. LTE

0. Show picture of the sun & structure of the sun.

1.1 Write down the RTE

$\boxed{\text{show question}}$



$$\frac{dI}{ds} = -\alpha I + j\rho$$

$\alpha ds =$
proportion of particles absorbed $= \dfrac{\text{total cross section}}{\text{geometric cross section}} = \dfrac{And s\sigma}{A}$

$= n\sigma ds.$

$= \rho k ds$

$= \frac{ds}{\lambda}$

Also $\lambda = \frac{1}{n\sigma}$ from $\underbrace{Ads}_{\text{Volume}} = \underbrace{\lambda\sigma}_{\text{cylinder volume,}}\underbrace{(Adsn)}_{N}$

$\boxed{\text{Dimensional analyses always work}}$

1.2. Optical depth.

$$d\tau = -k\rho ds \quad , \quad \tau = \int k\rho ds$$
(along path of photon)

~~Solution to the RTE has the~~
RTE can be written as

$$\frac{dI}{d\tau} = -I + S \quad , \text{where } S = \frac{\bar{j}}{k} \text{ "source function".}$$

$$\Rightarrow I(\tau) = I_0 e^{-\tau} + S(1 - e^{-\tau}).$$

$\boxed{\text{LTE means } S = B(T)}$ locally

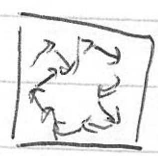
(Interlude – introduce the sun)

~~Maybe exercise 10.1.1?~~

~~(Temperature scale height vs mfp in the sun~~
~~→ LTE~~

2. Local thermodynamic equilibrium (LTE)

Idea: <u>Locally</u>, photons and gas interact enough such that the kinetic temperature of ~~photon~~ gas = effective temperature of photons (Kirchoff: source function $B = T$)



photons ~~are~~ stay in regions of roughly the same temperature.

Solar core:

~~pressure~~ ~~temperature~~ scale height

$$H_T \equiv \frac{T}{|dT/dr|} \sim \frac{\overset{8}{12}\times 10^6 K}{4\times10^6 K/(0.2R_\odot)} \sim 1.4\times10^{10} cm$$

Thomson scattering dominates in solar core (LOTS of electrons).

$$n \sim \frac{\rho}{0.5 m_H} = 5\times10^{31} m^3 = 5\times10^{25} cm^3$$

$$\sigma_T \sim 7\times10^{-25} cm^2$$

Mean free path

$$\lambda = \frac{1}{n\sigma_T} \sim \frac{1}{35} cm \ll H_T.$$

WHAT'S THE OPACITY ACROSS H_T?

3. Equations of stellar structure (so far)

$$\frac{dM_r}{dr} = 4\pi r^2 \rho$$

$$\frac{dP}{dr} = -G\frac{M_r \rho}{r^2}$$ (hydrostatic equilibrium).

$$\frac{dL_r}{dr} = 4\pi r^2 \rho \epsilon$$

$$\frac{dT}{dr} = -\frac{3}{4ac}\frac{\tilde{\kappa}\rho}{T^3}\underbrace{\frac{L_r}{4\pi r^2}}_{\text{Flux}}$$ (Energy transport by radiation).

[LTE gives local flux as function of T, opacity determines how energy is transported across temperature gradient].

Bonus question - calculate the radiation pressure & the gas pressure in the solar core.

Answer should be $P_{gas} >> P_{rad}$.