4-5pm 538 vector calc

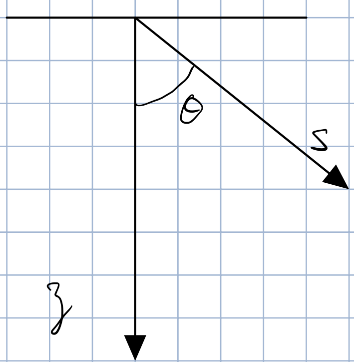
take sun

temp drop over couple cm

over little path, temp. practically is constant

WKB approximation

Radiative diffusion



@ large τ $I_\nu \to S_\nu$,

thermal radiation $S_0 = B_\nu(T)$

show that $F \propto \frac{dT}{dz}$

$\mu = \cos\theta$ $\mu = \frac{z}{s}$

$$ds = \frac{dz}{\cos\theta} = \frac{dz}{\mu}$$

$$\mu \frac{\partial}{\partial z}\left(I_\nu(z,\mu)\right) = -(\alpha_\nu + \sigma_\nu)(I_\nu - S_\nu)$$

$$I_\nu(z,\mu) = S_\nu - \frac{\mu}{\alpha_\nu + \sigma_\nu} \frac{\partial I_\nu}{\partial z}$$

Use zeroth order as first order correction

b/c $I_\nu^{(0)}(z,\mu) = S_\nu^{(0)}(z,\mu)$. $J_\nu^{(0)} = S_\nu^{(0)}$ $\Rightarrow$ $I_\nu^{(0)} = S_\nu^{(0)} = B_\nu$

$$I_\nu = I_\nu^{(0)} + I_\nu^{(1)} + \dots$$

$$I_\nu^{(1)} = I_\nu^{(0)} - \frac{\mu}{\alpha_\nu + \sigma_z} \cdot \frac{\partial}{\partial z}(B_\nu) \qquad \text{treat } I_\nu = I_\nu^{(0)}$$

now compute Flux

$$F_\nu(z) = \int I_\nu^{(1)}(z,\mu)\cos\theta \, d\Omega$$

$$= 2\pi \int_{-1}^{+1} I_\nu^{(1)}(z,\mu) \cdot \mu \, d\mu$$

bc B_ν is isotropic, it has no angular dependencies. integrating over all angles will make it zero. can neglect

$$F_\nu(z) = \frac{-2\pi}{\alpha_\nu + \sigma_z} \frac{\partial B_\nu}{\partial z} \cdot \int_{-1}^{+1} \mu^2 \, d\mu$$

$$B_\nu = B(\nu, T)$$

$$= \frac{-2\pi}{\alpha_\nu + \sigma_z} \frac{\partial B_\nu(T)}{\partial T} \cdot \frac{dT}{dz}$$

to get bolometric flux, integrate over all frequencies

$$F(z) = \int_0^{\infty} F_\nu(z) \, d\nu$$

$$= -\frac{4\pi}{3} \frac{dT}{dz} \cdot \int_0^{\infty} \frac{1}{(\alpha_\nu + \sigma_\nu)} \cdot \frac{\partial B_\nu}{\partial T} d\nu$$

indpt of ν

flux of heat / hot → cold

Stefan Boltzmann

$$\int_0^{\infty} \frac{\partial B_\nu}{\partial T} d\nu = \frac{4\sigma T^3}{\pi}$$

$$F(z) = \frac{-16\sigma T^3}{3\alpha_R} \frac{dT}{dz}$$

$$\alpha_R^{-1} = \frac{\int_0^{\infty} (\alpha_\nu + \sigma_\nu)^{-1} \cdot \frac{\partial B}{\partial T} d\nu}{\int_0^{\infty} \frac{\partial B_\nu}{\partial T} d\nu}$$

Rosseland absorption

all assuming temp. kinda stays same & very optically thick

Maxwell Equations

Lorentz Force: $\vec{F} = q\left(\vec{E} \times \frac{\vec{v}}{c} \times \vec{B}\right)$

proportion constant . introduced w/o speed of light mentioned.

gives meaning to electric field

admit charge for electric field like admit mass for gravitational field

Rate of doing work

$$\vec{v} \cdot \vec{F} = q\,\vec{v} \cdot \vec{E} \qquad (\vec{B} \text{ does no work})$$

for non-relativistic particles: $\vec{F} = m\frac{d\vec{v}}{dt}$

$$\frac{d}{dt}\left(\frac{1}{2} m \vec{v}^2\right) = q\vec{E} \cdot \vec{v}$$

electric field is only field to chang KE

generalize to distribution of charges & currents

$$\vec{f} = \rho \vec{E} + \frac{1}{c}\vec{j} \times \vec{B}$$

force per unit volume

charge density

$\rho = q\,\delta(\vec{x} - x_0)$

dirac delta f^n

current density

$\int f(x')\,\delta(x-x')\,dx' = f(x)$

corresponding eq^n for work done

energy/volume

$$\frac{d}{dt}\left(U_{mech}\right) = \vec{j} \cdot \vec{E}$$

Evolution of $\vec{E}$ & $\vec{B}$ governed by Maxwell's eqn

$$\vec{\nabla} \cdot \vec{D} = 4\pi\rho \qquad \vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial B}{\partial t} \qquad \vec{\nabla} \times \vec{H} = \frac{4\pi}{c}\vec{j} + \underbrace{\frac{1}{c}\frac{\partial D}{\partial t}}_{\text{displacement current}}$$

predicts waves

$$\vec{D} = \epsilon E$$
$$\vec{H} = \mu \vec{B}$$

in vaccum: $\epsilon = \mu = 1$

depends on units

$$\frac{\partial}{\partial t}(\underbrace{\rho}_{\text{density}}) + \vec{\nabla} \cdot \underbrace{\vec{F}}_{\text{flux}} = 0$$

$$\left[\frac{\text{stuff}}{\text{volume}}\right] + \left[\frac{\text{stuff}}{\text{area} \cdot \text{time}}\right] = 0 \rightarrow \text{conservation of stuff}$$

$$\vec{\nabla} \times \vec{F} = 0 \rightarrow \vec{F} = \vec{\nabla} \cdot \phi \qquad \text{irrotation}$$

$$\vec{\nabla} \cdot \vec{F} = 0 \rightarrow \vec{F} = \vec{\nabla} \times \vec{A} \qquad \text{solidoinal}$$

$$\vec{F} = \vec{F_I} + \vec{F_S}$$