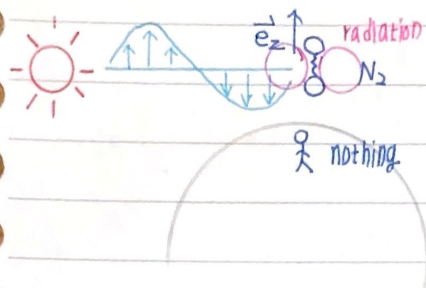
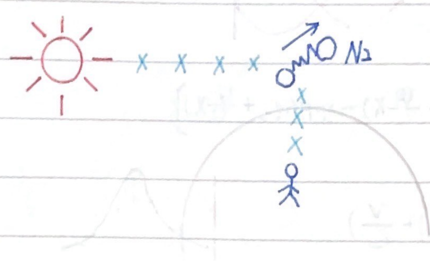
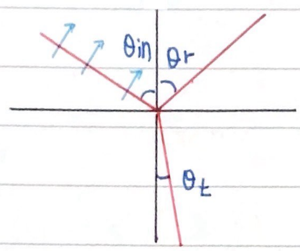
Let There Be Light

光的偏振方向是電場方向







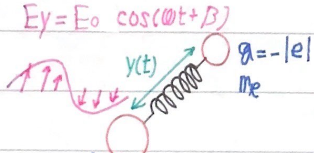
Brewster's angle

$$\theta_t = \frac{\pi}{2} - \theta_{in} \qquad \theta_t + \theta_r = \frac{\pi}{2}$$

$$n = \frac{\sin\theta_{in}}{\sin\theta_t} = \frac{\sin\theta_{in}}{\sin(\frac{\pi}{2}-\theta_r)} = \frac{\sin\theta_{in}}{\sin(\frac{\pi}{2}-\theta_{in})} = \frac{\sin\theta_{in}}{\cos\theta_{in}} = \tan\theta_{in}$$

why sky is blue

$E_y = E_0 \cos(\omega t + \beta)$



$$m_e\frac{d^2y(t)}{dt^2} = -ky(t) - b\frac{dy(t)}{dt} + qE_0\cos(\omega t+\beta), \quad m_e\frac{d^2y(t)}{dt^2} + ky(t) + b\frac{dy(t)}{dt} = qE_0\cos(\omega t+\beta)$$

let $y(t) = A\cos(\omega t+\beta+\alpha) \qquad \omega_0^2 = \frac{k}{m_e}$

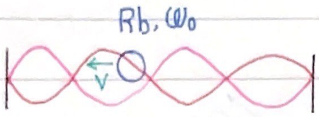
$$\rightarrow A\left[(\omega_0^2-\omega^2)\cos(\omega t+\beta+\alpha) - \frac{b\omega}{m_e}\sin(\omega t+\beta+\alpha)\right] = \frac{qE_0}{m_e}\cos(\omega t+\beta)$$

$$A = \frac{\frac{qE_0}{m_e}}{\sqrt{(\omega_0^2-\omega^2)+(\frac{b\omega}{m_e})^2}} \qquad a(t) = \frac{d^2y(t)}{dt^2} = -\omega^2 A\cos(\omega t+\beta+\alpha), \quad \omega_{vis} \ll \omega_{0_{N_2}}$$

$$\frac{dU}{dt} = \frac{q^2a^2}{6\pi\epsilon_0 c^3} = \frac{q^2}{6\pi\epsilon_0 c^3}\,\frac{\omega^4}{(\omega_0^2-\omega^2)^2+\frac{b^2}{m_e^2}\omega^2}\,\frac{qE_0}{m_e^2}\cos^2(\omega t+\beta+\alpha)$$

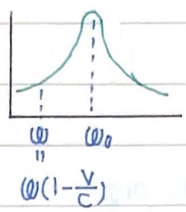
$$\approx \frac{q^4E_0^2}{6\pi\epsilon_0 c^3 m_e^2}\cos^2(\omega t+\beta+\alpha)\frac{\omega^4}{\omega_0^4} \quad \text{if } \omega \ll \omega_0$$

laser cooling

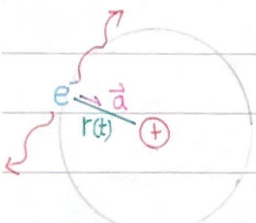


$$E_0\left[\sin\left(\omega t-\frac{\omega}{c}x\right)-\sin\left(\omega t+\frac{\omega}{c}x\right)\right]$$

if $\omega_0=\omega\left(1+\frac{v}{c}\right)$



atomic modle



$q=-|e|$

$$a=\frac{1}{m_e}\frac{1}{4\pi\epsilon_0}\frac{Z|e|q}{r^2(t)}$$

$$\frac{dU}{dt}=-\frac{q^2a^2}{6\pi\epsilon_0c^3}=-\frac{q^2}{6\pi\epsilon_0c^3}\frac{1}{m_e^2}\frac{1}{(4\pi\epsilon_0)^2}\frac{Z^2|e|^2q^2}{r^4(t)}$$

$$\|$$

$$U=-\frac{Z|e|}{4\pi\epsilon_0}\frac{q}{2r(t)},\quad \frac{dU}{dt}=\frac{Z|e|q}{8\pi\epsilon_0}\frac{1}{r^2(t)}\frac{dr}{dt}$$

$$\underbrace{\frac{-Z}{3\pi\epsilon_0c^3}\frac{|e^4|}{m_e^2}\frac{1}{4\pi\epsilon_0}}_{\Gamma}\frac{1}{r^2(t)}=\frac{dr(t)}{dt},$$

$$\int_0^{T_0}\Gamma\,dt=\int r^2(t)\frac{dr(t)}{dt}dt=\int_{r_0}^{0}r^2dr,\quad \Gamma T_0=\frac{1}{3}(0-r_0^3)$$

$$T_0=\frac{r_0^3}{3|\Gamma|},\quad T_0\le 10^{-10}\,s$$