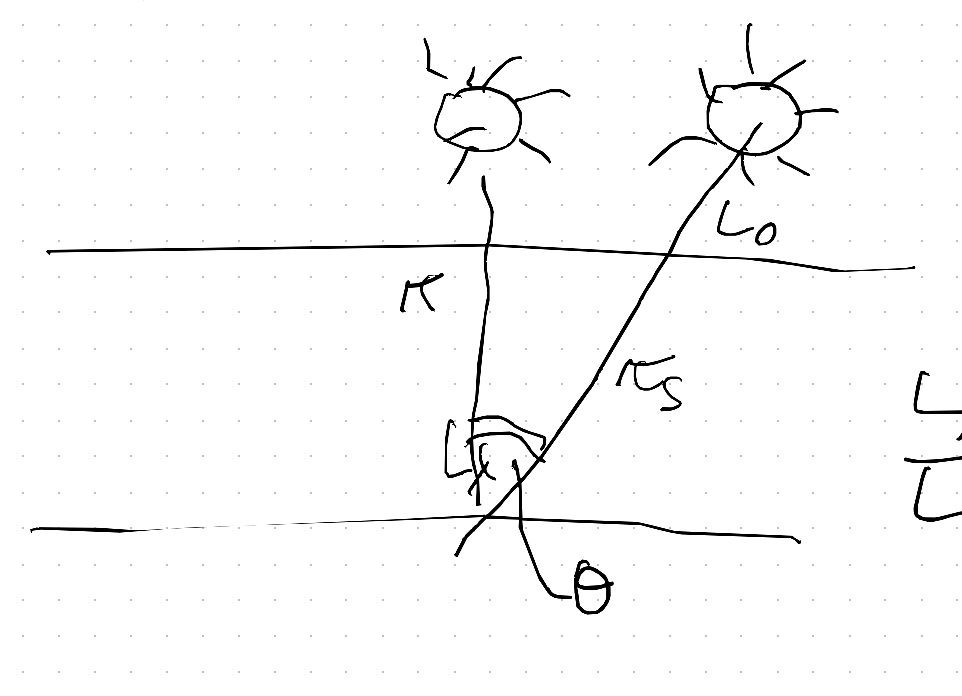
$$L_\lambda = L_0 \exp[-\tau]$$

$$\frac{L_\lambda}{L_0} = T = e^{-\tau} \qquad \tau = Kx$$

$$\tau = \int K dx$$

$$dL_\lambda = -K L_\lambda dx = -L_\lambda d\tau$$

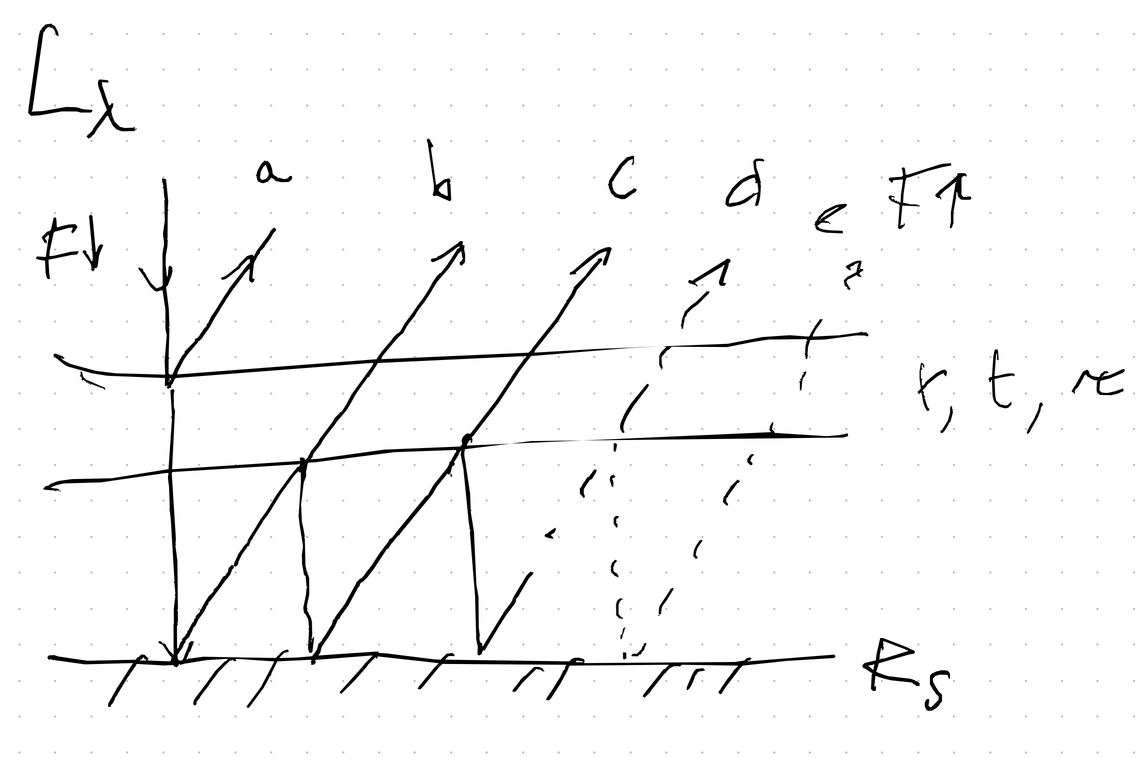


$$\frac{L_\lambda}{L_0} = e^{-\tau_s}$$

$$\frac{\tau}{\cos\theta} = \tau_s \qquad dL_\lambda = -k L_\lambda \frac{dz}{\cos\theta} = -L_\lambda \frac{d\tau}{\cos\theta}$$

$$\boxed{\frac{1}{\cos\theta} = m}$$ air mass factor $\qquad \theta \leq 60°$

$$dL_\lambda = -L_\lambda m d\tau$$



$$F\uparrow = a + b + c + d + \dots =$$

$$= \underbrace{F\downarrow r}_{a} + \underbrace{F\downarrow t R_s t}_{b} + \underbrace{F\downarrow t R_s r R_s t}_{c} +$$

$$+ F\downarrow t R_s r R_s r R_s t + \dots$$

$$\frac{F\uparrow}{F\downarrow} = r + tR_s t + tR_s r R_s t + \dots$$

$$A = r + t^2 R_s [1 + rR_s + (rR_s)^2 + (rR_s)^3 + \dots + (rR_s)^n]$$

$$\sum_1^n (1 + x^n) \simeq \frac{1}{1-x} \qquad \frac{1}{1 - rR_s}$$

$$A = r + \frac{t^2 R_s}{1 - rR_s}$$

$$\Delta A = r + \frac{t^2 R_s}{1 - rR_s} - R_s$$

$$\Delta A = A - R_s$$

$$\boxed{\omega = \frac{\tau_s}{\tau}}$$ single scattering albedo

$$\tau = \tau_s + \tau_a$$

$$0 \leq \omega \leq 1 \qquad \beta \rightarrow$$ fraction of backward scattering

$$r = (1 - e^{-\tau})\beta\omega$$

$$t = e^{-\tau} + \omega(1-\beta)(1 - e^{-\tau})$$

$$\tau \ll 1$$

$$1 - e^{-\tau} \simeq \tau \qquad r \simeq \tau\beta\omega$$

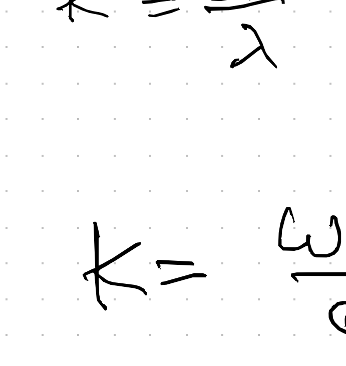
$$e^{-\tau} = 1 - \tau \qquad t = 1 - \tau + \omega\tau(1-\beta)$$

$$\Delta A = r + \frac{t^2 R_s}{1 - rR_s} - R_s \simeq \tau\omega\beta + \frac{R_s[1 - \tau + \omega\tau(1-\beta)]^2}{1 - \tau\omega\beta R_s} -$$

$$\Delta A = \tau \frac{-2R_s + \omega[\beta + 2R_s(1-\beta) + \beta R_s^2]}{1 - \tau\omega\beta R_s}$$

$$\Delta A \qquad \tau = 0 \qquad \Delta F\uparrow = \Delta A \cdot F\downarrow$$

$$\omega_c = \frac{2R_s}{2R_s + \beta(1 - R_s)^2}$$



$$E_x = E_0 \exp[i(\omega t - kz)]$$

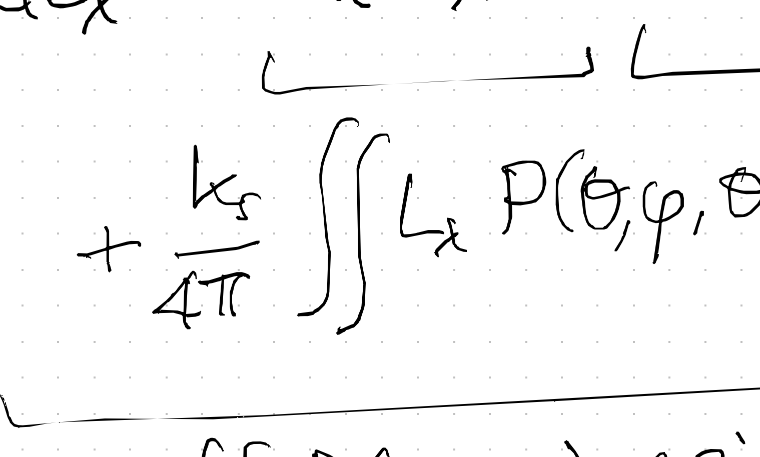
$$k = \frac{2\pi}{\lambda} \qquad v = \frac{c}{m} = \frac{\omega}{k}$$

$$k = \frac{\omega m}{c} = \frac{\omega}{c}[m - im']$$

$$E_0 = E_0 \exp\left[i\left(\omega t - \frac{\omega}{c}(m - im')z\right)\right] =$$

$$= E_0 \underbrace{\exp\left[i\left(\omega t - \frac{\omega}{c} m z\right)\right]}_{\text{oscillation}} \cdot \exp\left[-\frac{\omega}{c} m' z\right]$$

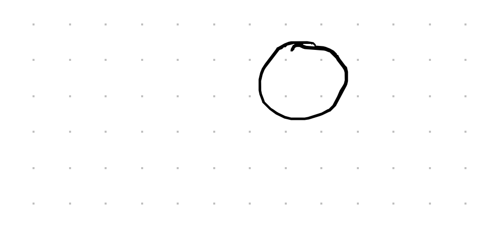
$$\exp\left[-\frac{z}{L_a}\right] \qquad \boxed{L_a = \frac{c}{\omega m'}}$$



$$dL_\lambda = -K_a L_\lambda dx - K_s L_\lambda dx + \frac{K_s}{4\pi}\iint L_\lambda P(\theta, \varphi, \theta', \varphi') d\Omega'$$

$$\iint P(\Omega, \Omega') d\Omega' = 4\pi$$

Rayleigh $\boxed{r \ll \lambda}$

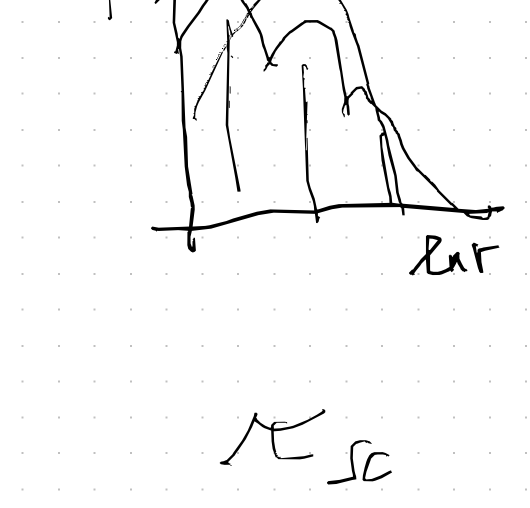


$$P(\theta) = c(1 + \cos^2\theta)$$

$$\frac{\sigma_{sc}}{\pi r^2} = Q_{sc}(x, m, m')$$

$$K = n_n \sigma_a$$

$$\tau = \int K(z) dz$$



$$\frac{dn_p}{dr} \qquad \tau = \int dz \int \frac{dn_p}{dr} \pi r^2 Q_{ext}(r, \lambda, m, m') dr$$

$\tau_{sc} \qquad Q_{sc}$

$\tau_{ab} \qquad Q_{ab}$