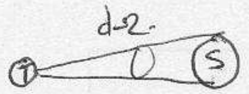
TD 5 (1A

1)



$$\boxed{d\Omega = \frac{dS}{R^2}} \quad \text{ou} \quad \boxed{\Omega = \frac{S}{R^2}}$$

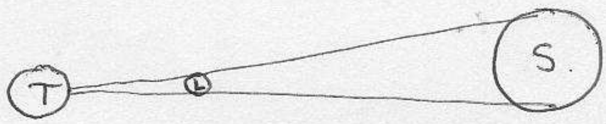
Ω_{ST} : $S = \cancel{4}\pi R_S^2$, $R = d_{TS}$ $\quad \Omega_{ST} = \frac{\cancel{4}\pi R_S^2}{d_{TS}^2} = \frac{\cancel{4}\pi\,(695.10^6)^2}{(149\times10^6.10^3)^2} = \underline{6{,}84.10^{-5}\ sr}$

Ω_{TS} : $S = \pi R_T^2$, $R = d_{TS}$ $\quad \Omega_{TS} = \frac{\pi R_T^2}{d_{TS}^2} = \frac{\pi\,.(6380.10^3)^2}{(149\times10^6.10^3)^2} = \underline{5{,}76.10^{-9}\ sr}$

Ω_{LT} : $S = \pi R_L^2$, $R = d_{TL}$ $\quad \Omega_{LT} = \frac{\pi.R_L^2}{d_{TL}^2} = \frac{\pi.(1740.10^3)^2}{(384.10^3.10^3)^2} = \underline{6{,}45.10^{-5}\ sr}$

Ω_{TL} : $S = \pi R_T^2$, $R = d_{TL}$ $\quad \Omega_{TL} = \frac{\pi R_T^2}{d_{TL}^2} = \frac{\pi\,(6380.10^3)^2}{(384.10^3.10^3)^2} = \underline{8{,}67.10^{-4}\ sr}$

éclipse de soleil.

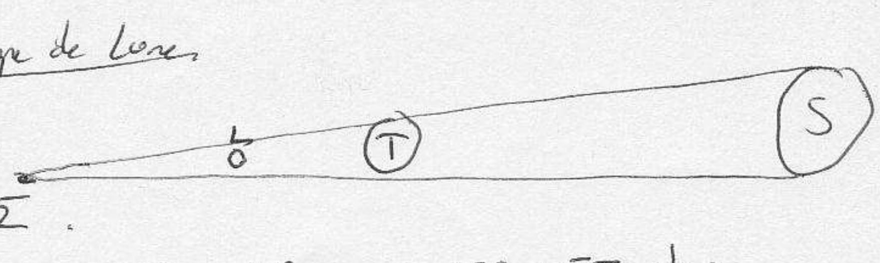


$\Omega_{ST} = 6{,}84.10^{-5}\ sr.$

$\Omega_{LT} = 6{,}45.10^{-5}\ sr$

$\Omega_{LT} < \Omega_{ST} \Rightarrow$ le soleil n'est pas complètement caché par la Lune ! Comme $\Omega_{ST} \simeq \Omega_{LT}$, cette éclipse n'est visible que dans une zone très étroite.

éclipse de Lune



$$\frac{\Sigma S}{\Sigma T} = \frac{2R_S}{2R_T} \quad \text{et} \quad \Sigma S = \Sigma T + d_{TS}$$

$$\Rightarrow 1 + \frac{d_{TS}}{\Sigma T} = \frac{R_S}{R_T} \Rightarrow \Sigma T = \frac{d_{TS}}{\frac{R_S}{R_T} - 1} = \frac{149.10^9}{\frac{695.10^6}{6380.10^3} - 1}$$

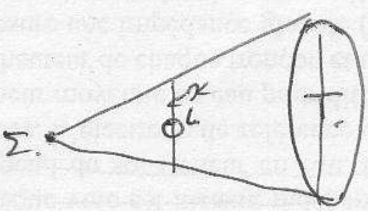
$$\underline{\Sigma T = 1{,}3805.10^9\ m.}$$

B

$$\Omega_{T\Sigma} = \frac{\pi R_T^2}{(\Sigma T)^2} = \frac{\pi\,(6380\cdot 10^3)^2}{(1,3805\cdot 10^9)^2} = 6,71\cdot 10^{-5}\ \text{sr.}$$

$$\Omega_{L\Sigma} = \frac{\pi R_L^2}{(\Sigma L)^2} = \frac{\pi R_L^2}{(\Sigma T - d_{TL})^2} = \frac{\pi\,(1740\cdot 10^3)^2}{(1,3805\cdot 10^9 - 384\cdot 10^6)^2} = 9,59\cdot 10^{-6}\ \text{sr.}$$

$\Rightarrow \Omega_{L\Sigma} \ll \Omega_{T\Sigma} \Rightarrow$ la Lune peut entrer complètement dans le cone d'ombre $\Rightarrow$ éclipse totale, pour une surface assez étendue au sol de la Terre.

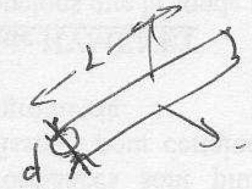


$$\frac{x}{R_T} = \frac{\Sigma L}{\Sigma T} \Rightarrow x = R_T\,\frac{\Sigma L}{\Sigma T} = 6380 \times \frac{(1,3805\cdot 10^6 - 384\cdot 10^3)}{1,3805\cdot 10^6}$$

$$x = 4605\ \text{km}$$

$\Rightarrow 2,5$ Lunes.

2°)



$$\phi = M_T^0 \cdot S = \sigma . T^4 . S = \sigma T^4 . \pi d . L$$

$$\Rightarrow T = \left(\frac{\phi}{\sigma\pi . d . L}\right)^{1/4} = \frac{1000}{5,67\cdot 10^{-8}\times\pi\times 2\cdot 10^{-2}\times 0,5} = \underline{\underline{865,6\,K}}$$

Loi de Wien $\Rightarrow \lambda_m T = 2,897\cdot 10^{-3}$ mK

$\Rightarrow \lambda_m = 3,347\cdot 10^{-6}$ m $= \underline{\underline{3,347\ \mu m}}$

Loi de Wien $\Rightarrow$ pour $\lambda_m = 2\,\mu m \Rightarrow T = \frac{2,897\cdot 10^{-3}}{2\cdot 10^{-6}} = 1448,5$ K.

Puissance dégagée proportionnelle à σT^4.

$$\phi_1 = \sigma T_1^4,\quad \phi_2 = \sigma T_2^4 \Rightarrow \phi_2 = \phi_1\left(\frac{T_2}{T_1}\right)^4 = 1\cdot 10^3 \times \left(\frac{1448,5}{865,6}\right)^4$$

$$\underline{\underline{\phi_2 = 7842\ W}}$$

3°)

a) Terre = corps noir à $T_T = 300K$

$$\Rightarrow \Phi = \sigma T_T^4 . S_T = \sigma T_T^4 . 4\pi R_T^2$$

$$= 5,67.10^{-8} \times 300^4 . 4\pi . (6,38.10^6)^2 \qquad \underline{\Phi = 2,35.10^{17}\ W}$$

b) · Emittance du soleil

$$M^\circ = \sigma T_S^4 = 5,67.10^{-8} . 5800^4 = \underline{6,42.10^7}\ W/m^2$$

Luminance (émission isotrope)

$$L^\circ = \frac{M^\circ}{\pi} = \underline{2,04.10^7}\ W/m^2.sr.$$

or depuis le soleil, la Terre est vue sous l'angle solide $\Omega = \frac{\pi R_T^2}{d_{T-S}^2} = \Omega_{TS}$

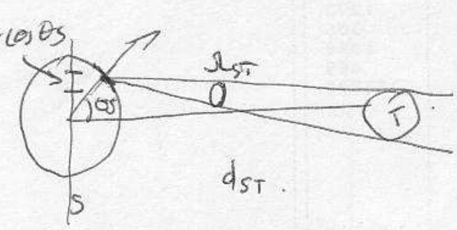
$\underline{\Omega = 5,76.10^{-9}}$ sr. exercice 1

soit $\phi = L^\circ . \Omega = 0,1175\ W/m^2$

↑ de surface apparente de la source.

Donc. $\Phi = \phi . S = \phi \pi R_S^2 = 0,1175 \times \pi . (695.10^6)^2 = \underline{1,78.10^{17}\ W.}$

OU · $E = \frac{d\phi_S}{dS_T} = L_S . \frac{dS_S \cos\theta_S . \cos\theta_T}{d_{TS}^2} \Rightarrow \Phi = \int E . dS_T = \int L_S \frac{dS_S \cos\theta_S \cos\theta_T . dS_T}{d_{TS}^2}$



$$\Phi = \int L_S . \frac{\cos\theta_T . dS_T}{d_{TS}^2} . \boxed{\pi R_S^2}$$

$$\boxed{\pi R_S^2} = \int dS_S . \cos\theta_S .$$

$$\Phi = \frac{\sigma T_S^4}{\pi} . \pi R_S^2 . \Omega_{TS}$$

$$= 5,67.10^{-8} \times 5800^4 \times (695.10^6)^2 \times 5,76.10^{-9}$$

$$\Phi = 1,78.10^{17}.\ W.$$

$\Rightarrow \Phi$ perdu par la Terre $> \Phi$ reçu du soleil $\Rightarrow$ la Terre se refroidit constamment !

c) ~~Eclairement reçu par la Terre (du soleil)~~

$$\cancel{E = \frac{\Phi}{4\pi R_T^2} = \frac{1,78 \cdot 10^{17}}{4\pi \cdot (6,38 \cdot 10^6)^2} =}$$

Si équilibre ⇒ Flux perdu par la Terre = flux reçu du soleil.

$$\underbrace{\sigma T_{Te}^4}_{W/m^2} \times \underbrace{4\pi R_T^2}_{m^2} = \Phi = 1,78 \times 10^{12}$$

$$\Rightarrow T_{Te} = \left(\frac{\Phi}{\sigma 4\pi R_T^2}\right)^{1/4} = \frac{1,78 \cdot 10^{17}}{5,67 \cdot 10^{-8} \cdot 4\pi (6,38 \cdot 10^6)^2}$$

$$T_{Te} = 279,9\ K.\ (= 6,75\ °C).$$

c'est froid !!

d) Terre à 27° ⇒ $\Phi = 2,35 \cdot 10^{17}\ W$ (cf question a))

+ effet de serre ⇒ Φ_{serre}

+ flux solaire ⇒ $\Phi = 1,78 \cdot 10^{17}\ W$

$$\Rightarrow \Phi_{terre} = \Phi_{soleil} + \Phi_{serre} \Rightarrow \Phi_{serre} = 2,35 \cdot 10^{17} - 1,78 \cdot 10^{17}$$

$$\underline{\Phi_{serre} = 0,57 \cdot 10^{17}\ W.}$$

pour $T_{Te} = 300\ K$ (27 °C)

e). $\Phi_{soleil} + 1,2\,\Phi_{serre} = \sigma T_{Te}^4 \cdot 4\pi R_T^2$

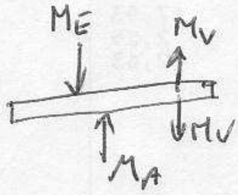
$$\Rightarrow T_{Te} = \left(\frac{\Phi_{soleil} + 1,2\,\Phi_{serre}}{\sigma 4\pi R_T^2}\right)^{1/4} = 303,6\ K\ (30,45\ °C).$$

d'où une augmentation de $\underline{3,6\ K}$.

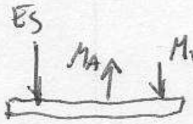
4°) $\lambda T = 2,897 \cdot 10^{-3}$ mK

a) $T = 5800 \rightarrow \lambda_m = 0,5\,\mu m \Rightarrow$ visible $(0,3 \rightarrow 3\,\mu m)$.

$T = 300 \rightarrow \lambda_m = 10\,\mu m \rightarrow$ IR.

b) 

$$-M_E - M_A + 2M_V = 0$$



$$-E_S + M_A - M_V = 0$$

c) $M_E = \sigma T_E^4$

$M_A = \sigma T_A^4$

$M_V = \sigma T_V^4$

$$-\sigma T_E^4 - \sigma T_A^4 + 2\sigma T_V^4 = 0$$

$$-E_S + \sigma T_A^4 - \sigma T_V^4 = 0$$

T_V inconnue $\Rightarrow$ on essaye de la virer des éq^{e}

$$-E_S + \sigma T_A^4 - \frac{1}{2}\left(\sigma T_E^4 + \sigma T_A^4\right) = 0$$

$$\frac{1}{2}\sigma T_A^4 = \frac{1}{2}\sigma T_E^4 + E_S$$

$$\Rightarrow T_A^4 = T_E^4 + \frac{2E_S}{\sigma}$$

$$T_A = \left(300^4 + \frac{2 \times 1.10^3}{5,67.10^{-8}}\right)^{1/4} = 456\text{ K}$$

$(> 180°C)$.

d) sans la vitre.

$$-E_S - M_E + M_A = 0 \Leftrightarrow -E_S - \sigma T_E^4 + \sigma T_A^4 = 0.$$

$$T_A^4 = \frac{E_S + \sigma T_E^4}{\sigma} = 300\text{ K}.$$

$(27°C)$.