$\frac{\partial L_f}{\partial f}$

Remote Sensing Data Acquisition, 11 January 2022

UNIVERSITÀ DEGLI STUDI DI BRESCIA

$(f \cdot g)' = f'g + g'f$

$\frac{\partial L_f}{\partial f} = \frac{2h}{c^3} 5f^4 \left(\frac{1}{e^{x(f)}-1} \right) + \frac{\frac{h}{k_B T} e^x}{(e^x-1)^2} \frac{2hf^5}{c^3}$ $\quad \left(\frac{1}{f}\right)' = \frac{f'}{f^2}$ $\quad \left(\frac{1}{x^n}\right)' = \frac{x^n}{x^{2n}}$

Exercise 1

a) Define the following radiometric quantities and write explicitly their units of measurement:
- radiance,
- irradiance,
- radiant exitance.

$\frac{\partial L_f}{\partial f} = \frac{10hf^4}{c^3} \frac{1}{e^x} k_B T + \frac{h e^x}{k_B T e^x} \cdot \frac{2hf^5}{c^3} = 0$

$= \cancel{10}hf^4 k_B T + 2h f^5 e^x = 0 \rightarrow f = \frac{-5 k_B T}{h e^x} = \frac{c}{\lambda}$

b) Write the formula for the spectral radiance of the black body as a function of the wavelength and explain its meaning. $\lambda = \frac{hc\, e^x}{5 k_B T}$

c) Starting from the definitions of emissivity and brightness temperature explain how the thermal radiation of any object can be described.

d) Starting from the result of point b) obtain the formula of the spectral radiance of the black body as a function of the frequency. $e^x - 1 \simeq e^x$

$\frac{\partial L_\lambda}{\partial \lambda} = 0$

XX e) Starting from the result of point b) obtain an approximate formula for the wavelength of maximum spectral radiance; comment this result. $\lambda_{max} = \frac{A}{T}$ $\quad A = 2.3 \cdot 10^{-3}$

Wien's law

f) Plot qualitatively the spectral radiance of the black body for the following 3 temperatures: -100 °C, 0 °C, 2000 °C.

a b.b. absorbs all the radiation that emitted to it but the other materials do not. Their absorption is related to a coeff. called emissivity that is depend on λ.

temperature of an equivalent b.b. that has the same L_λ on the same wavelength T_B

$= \frac{1}{\exp\left(\frac{hf}{k_B T}\right) - 1}$

$\frac{c^2}{\lambda^2 \cdot \lambda^3}$ $\quad \frac{c^2}{\lambda^5}$

$\frac{f^2 \cdot f^3}{c^3}$

$\frac{2hf^5}{c^3}$

$f = \frac{c}{\lambda}$

$\lambda = \frac{c}{f}$

$\frac{1}{\lambda^3} = \left(\frac{f}{c}\right)^3$

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Exercise 2

a) Describe a simple aerial photographic system based on a single lens camera.

b) Define the f/number of a lens and explain why this parameter is important in a photographic system.

c) Define the resolution of a photographic film and, in the case of a single lens camera placed on a satellite, derive a formula for the film limited resolution on the ground.

r $r_g = \frac{1}{2r} \cdot \frac{H}{f}$

d) Explain how the resolution of a single lens camera is limited by diffraction and obtain a formula for the diffraction limited resolution on the ground.

do it later

e) Let us consider a camera on board of a satellite orbiting at an altitude of 200 km, the film has a resolution of 150 lp/mm, the lens has a diameter of 8 cm and a focal length of 120 mm: is the ground resolution of the photos taken by the camera in the near infrared wavelength range limited by diffraction or by the film resolution? Justify the answer.

visible | IR

700 nm →

b) $\frac{f}{\text{nbr of cam}}$: = $\frac{\text{total radiance}}{\text{irradiance}}$, depends on $\left(\frac{f}{D}\right)$ characterise a lens

$\frac{f}{\text{nbr of lens}}$: it defines the brighten of the image . the brighter the image the higher the D of a lens is , the bigger the lens , we use multiple
↳ to avoid using ~~multip~~ one big lens , we use an equivalent that give the equivalent result with an equivalent focal point . It categorize the system , how many lenses needed for the value of f needed to get the wanted brightness .

$S_x = \frac{1}{2r}$ / $s = \frac{f}{H}$ —

$r_g = \frac{S_x}{s} = \frac{1}{2r} \cdot \frac{H}{f}$ —

$w_g = \frac{w}{s} = w \frac{H}{f}$ —

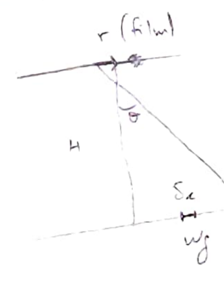
$\tan\theta = \frac{w_g}{H}$ $\theta <<$ $w_g \to S_x$

$\theta = \frac{S_x}{H}$ $\theta = 1.22 \frac{\lambda}{D}$

$S_x = \theta \cdot H$

$S_x = 1.22 \cdot \frac{\lambda}{D} \cdot H$

$r_g = \frac{S_x}{s} = 1.22 \frac{\lambda}{D} \cdot \frac{H}{f}$



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Exercise 3

be more precise [real day] X

a) Explain the meaning and importance of the following types of satellite orbits: polar, geosynchronous, geostationary. explain the inclination angle [same period] [equator]

b) Explain how the motion of a two-dimensional detector array placed on a satellite can be exploited to acquire an image of a very large portion of the Earth's surface.

c) Explain how the motion of a linear (one-dimensional) detector array placed on a satellite can be exploited to acquire an image of a very large portion of the Earth's surface.

$$r_s = \frac{1}{2r}\,\frac{H}{f} = \frac{1}{2 \times \frac{150\ lp}{1\ mm}} \times \frac{200 \times 10^3\ m}{120\ mm}$$

(m/lp)

$$= 5.55\ (m/lp)$$