Esercizio (pag 46)

IQE = 20 elettroni /sec
Nd = 5 elettroni /sec
Nr = 5 elettroni

Calcola SNR con tempo di esposizione: 1) t = 50s
2) t = 0,5s
3) t = 0,5s e F = 100

1) $$SNR = \frac{IQEt}{\sqrt{IQE \cdot t + Ndt + Nr^2}} = \frac{20 \cdot 50}{\sqrt{20 \cdot 50 + 5 \cdot 50 + 5^2}} = 28$$

2) $$SNR = \frac{IQEt}{\sqrt{IQE \cdot t + Ndt + Nr^2}} = \frac{20 \cdot 0{,}5}{\sqrt{20 \cdot 0{,}5 + 5 \cdot 0{,}5 + 5^2}} = 1{,}63$$

3) $$SNR = 1{,}63 \cdot \sqrt{F} = 1{,}63 \cdot 10 = 16{,}3$$

Esercizio (pag 48)

8-bit converter
Maximum voltage = 10V
Calcola il dynamic range

valori codificabili = $2^8 = 256$
Minimum voltage = $V_{max}/2^8 = 10V/256 = 0{,}039V$
dynamic range = $20 \log_{10} \frac{V_{max}}{V_{min}} = 48{,}16 dB$

Esercizio (pag 71)

The altitude of an imaging satellite is 350 kilometers. If a biologist wants to study deforestation in plots of land 10-meters across, what will be the minimum angular resolution of the CCD camera system used on the satellite?

$d = 350 \cdot 10^3 m$ $\quad L = 10 m$

$$\Theta = \frac{L}{d} = \frac{10}{350000} rad = \frac{10}{350000} \cdot \frac{180}{\pi} deg = \frac{10}{350000} \cdot \frac{180}{\pi} \cdot 60 \times 60 \text{ arcsec} = 5{,}9 \text{ arcsec}$$

Esercizio (pag 71)

The Lunar Reconnaissance Orbiter operates from a lunar altitude of 60 kilometers. What is the resolution of the CCD imager which can resolve details at a level of 1-meter per pixel?

$d = 60 \cdot 10^3 m$ $\quad L = 1m/pix$

$$\Theta = \frac{1}{60 \cdot 10^3} \cdot \frac{180}{\pi} \, 60 \times 60 = 3{,}44 \text{ arcsec}$$

Esercizio (pag 71)

The Solar Dynamics Observatory (SDO) has an imaging system with 1 arcsecond per pixel resolution. At a distance of 150 million kilometers, what is the resolution of this system in kilometers per pixel?

$\theta = 1$ arcsec/pixel $\qquad d = 150 \cdot 10^6$ km $\qquad L = ?$

$$\theta = 1 \text{ arcsec} = \frac{1}{60^2} \text{ deg} = \frac{1}{60^2} \frac{\pi}{180} = 4{,}848 \cdot 10^{-6} \text{ rad}$$

$$\theta = \frac{L}{d} \Rightarrow L = d \cdot \theta = 150 \cdot 4{,}848 = 727 \text{ km/pix}$$

Esercizio (pag 72)

The ISS is 100x80 m and orbits Earth at an average altitude of 420 kilometers above Earth. I want to take a picture of ISS (4 m per pixel). Find minimum focal length required (pixel size = 6 μm).

$d = 420 \cdot 10^3$ km

1) Considero $\quad L = 4\text{m/pix} \Rightarrow DES = 6 \cdot 10^{-6}$ m (dimensione corrispettiva sul sensore di un'immagine reale di 4m (1 pixel))

$$\theta = IFOV = \frac{L}{d} = \frac{4}{420 \cdot 10^3} = 9{,}523 \cdot 10^{-6}$$

$$IFOV = \frac{DES}{FL} \Rightarrow FL = \frac{DES}{IFOV} = \frac{6 \cdot 10^{-6}}{9{,}523 \cdot 10^{-6}} = 630 \text{ mm}$$

2) Considero $\quad L = 100\text{m} \Rightarrow DES = \underbrace{\frac{100\text{m}}{4\text{m/pix}}}_{\text{n° pixels}} \cdot 6 \cdot 10^{-6}\text{m} = 0{,}15 \cdot 10^{-3}\text{m}$ (dimensione corrispettiva sul sensore di un'immagine reale di 100 m (25 pixels))

$$\theta = IFOV = \frac{L}{d} = \frac{100\text{m}}{420 \cdot 10^3\text{m}} = 0{,}238 \cdot 10^{-3} \text{ rad}$$

$$IFOV = \frac{DES}{FL} \Rightarrow FL = \frac{DES}{IFOV} = \frac{0{,}15 \cdot 10^{-3}}{0{,}238 \cdot 10^{-3}} = 630 \text{ mm}$$

Esercizio Telescopio Keck

Diametro del telescopio $= 8'' = \frac{8}{39,37} m = 20,3 cm$

$d = 10 m$ diametro degli specchi primari

$\lambda = 500 nm$

$LGP = \left(\frac{\text{diametro telescopio}}{\text{diametro occhio}}\right)^2 = \left(\frac{20,3 m}{0,5 m}\right)^2 = 1648$ (Il telescopio può percepire 1648 volte più luce dell'occhio)

$RP = \theta = 1,22 \frac{\lambda}{d} = 61 \cdot 10^{-9}$ rad $= 0,01258$ arcsec

La risoluzione dell'occhio è, teoricamente, 1 arcmin = 60 arcsec

$\frac{RP_{keck}}{RP_{eye}} = \frac{0,01258}{60} = 4769$ La risoluzione del telescopio Keck è 4769 volte maggiore di quella dell'occhio

Dimensione angolare della luna piena $= 0,5°$
$d = 20,3 cm$
$\lambda = 500 nm$
f-number $= 10$

RP? Linear Size?

$RP = 0,22 \frac{\lambda}{d} = 0,22 \frac{500 \cdot 10^{-9}}{20,3 \cdot 10^{-2}} = 3,004 \cdot 10^{-6}$ rad $= 0,62$ arcsec

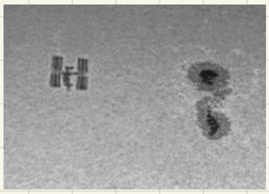
$f\text{-number} = \frac{f}{d} \Rightarrow f = f\text{-number} \cdot d = 2,03 m$

Linear size $= \theta \cdot \frac{\pi}{180} \cdot f = 0,5° \frac{\pi}{180°} \cdot 2,03 m = 0,0177 m = 1,77 cm$

$\theta(rad) = \frac{L(LS)}{d(f)}$

Esercizio (slide 478)

The ISS is 108 meters wide, and was at an altitude of 350 km when this photo was taken. If the sun is at a distance of 150 million kilometers, how large is the sunspot in kilometers? How large is the sunspot compared to the size of Earth if the diameter of Earth is 13,000 km?



ISS: $L = 108 m$ $d = 350 \cdot 10^3 m$ $\longrightarrow$ $\theta = \frac{L}{d} = \frac{108}{350 \cdot 10^3} = 3,086$ rad $= 63$ arcsec

Sun: $\theta = 63$ arcsec $d = 150 \cdot 10^9 m$ $\longrightarrow$ $L = \theta d = 3,086$ rad $\cdot 150 \cdot 10^9 m = 46286$ Km

La macchia solare ha quindi una grandezza di circa 46000 x 92000 Km, ossia 3 e 7 volte il diametro della terra.

Esercizio (pag 82)

If a pattern of stripes consists of a difference of 6 aperture stops between the brightest and darkest points, compute the contrast of the object.

6 stops $= 2^6 = 64$ intervalli

$$\text{contrast} = \frac{64-1}{64+1} = 0{,}97$$

How many aperture stops are required for MT=50% ?

$$MT = 0{,}5 = \frac{\text{contrast of the image}}{\text{contrast of the object}} \Rightarrow \text{contrast of the image} = 0{,}5 \cdot 0{,}97 = 0{,}48$$

$$\text{Contrast} = 0{,}48 = \frac{x-1}{x+1} \Rightarrow 0{,}48x + 0{,}48 = x - 1 \Rightarrow 0{,}52x = 1{,}48 \Rightarrow x = 2{,}8$$ numero di intervalli

$\log_2 2{,}8 = 1{,}5$ stops