Section 6 - Exercise #3 and 9

McLean seminar
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Section 6 – Exercise #3

3. Match the following three detectors to a **0.2m** telescope (2″ seeing) and then to an **8m** telescope (0.5″ seeing):
- a Kodak KAF-4200 CCD with **9 micrometer pixels in a 2048 x 2048** format,
- a SITe CCD with **22 micrometer pixels in a 1024 x 1024** format,
- a Raytheon InSb array with **27 micrometer pixels in a 1024 x 1024** format.

Assume Nyquist sampled seeing of **2″ and 0.5″** respectively.

$$\text{Pixel Scale} \propto \frac{\text{Pixel Size}}{D}$$

[1]. 0.2m telescope (2″ seeing)

1. Kodak
   - pixle size: 9 μm -> pixel scale = 9 μm / 0.2m = 45 μm/m

2. SITe
   - pixle size: 22 μm -> pixel scale = 22 μm / 0.2m = 110 μm/m

3. Raytheon
   - pixle size: 27 μm -> pixel scale = 27 μm / 0.2m = 135 μm/m

➔ Pixel scale of 110 relative units, which would be close to the 2'' seeing.
➔ SITe detector is suitable for 0.2m telescope

[2]. 8m telescope (0.5″ seeing)

1. Kodak
   - pixle size: 9 μm -> pixel scale = 9 μm / 8m = 1.125 μm/m

2. SITe
   - pixle size: 22 μm -> pixel scale = 22 μm / 8m = 2.75 μm/m

3. Raytheon
   - pixle size: 27 μm -> pixel scale = 27 μm / 8m = 3.375 μm/m

➔ pixel scale of 1.125 relative units, which is ideal for 0.5'' seeing.
➔ Kodak detector is suitable for 8m telescope

Section 6 – Exercise #9

9 An infrared cryostat has a surface area of $5\,m^2$. Assuming that the geometric factor is one-half the emissivity of 5%, calculate the radiation load on a 77 K interior from (a) laboratory temperature of 300 K and (b) mountain observatory temperature of 275 K. What could you do to reduce the load on the internal cold components?

Stefan-Boltzmann law for radiative heat transfer:

$$Q = \sigma \cdot A \cdot \epsilon \cdot G \cdot \left(T_{\text{ext}}^4 - T_{\text{int}}^4\right)$$

σ: Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ W/m^2K^4$)
A: surface area of the cryostat ($5\ m^2$)
ϵ: emissivity (5%)
G: geometric factor (which is given as half the emissivity)

(a) Laboratory temperature (T_{ext} = 300K)

$Q_{300K} = \sigma \cdot A \cdot \epsilon \cdot G \cdot (300^4 - 77^4) = 57W$

(b) Mountain observatory temperature (T_{ext} = 275K)

$Q_{275K} = \sigma \cdot A \cdot \epsilon \cdot G \cdot (275^4 - 77^4) = 40W$

To reduce the load on the internal cold component, adding multi-layer insulation is one of possible solution. It can reduce radiative heat transfer significantly by reflecting radiation away from the cold surfaces.