S&G – Observational Techniques – Homework Set 1 – Solutions

[Remember: 1° =60′ = 3600″ and 360° = 2π rads, so 1 rad = 206265″]

1) $m_1 - m_2 = -2.5\log(f_1\,/\,f_2)$ with $f_1\,/\,f_2 = 3$ and $m_2 = 10$ gives $\underline{m_1 = 8.80}$ [1 mark]

2) Prime Focus. Advantages: used for wide field imaging or spectroscopy **or** the image at the prime focus is aberation free if the mirror is a parabola.

Cassegrain Focus. Advantages: compact, but retain long focal length **or** instruments can be placed on outside of telescope.

Coude Focus. Advantages: Used for heavy/bulky and/or sensitive instruments.

Naysmith focus: gravity stable, so used for sensitive instruments (or adaptive optics).

[2 marks for any combination]

3) Plate scale:

$1\,/\,f = d\theta\,/\,dS$ where f is the focal length.

$1\,/\,f = 2.34\times10^{-3}\,/\,206265$

(the factor 206265 converts from arcseconds / m to radians / m).

This gives an effective focal length, $f = 88.14$ m.

Finally:

f-ratio $= f\,/\,D$

f-ratio $= 88\,/\,8 = 11$.

So f-ratio is f/11. [2 marks]

4) The f-ratio is f/3, so the effective focal length, f, is

$f\,/\,D =$ f-ratio $= 3$.

Hence $f = 12$ m.

The plate scale is: $d\theta\,/\,dS = 1\,/\,f = 0.083$ rads / m

$d\theta\,/\,dS = 17.18''\,/\,$mm.

The detector has $1000\times15\,\mu$m pixels and so the detector is 15 mm on a side. Hence, the maximum field of view is:

$17.18''\,/\,\text{mm}\times15\,\text{mm}\ \underline{= 257''}$ [2 marks]

5) *(i)* From Rayleighs criterion, $\theta = 1.22\,\lambda\,/\,D$ [with λ=wavelength, D=diameter]

$\theta = 1.22\times(550\times10^{-9})\,/\,8\times206265$

$\theta = 0.017''$

$\underline{\theta = 17.3\,\text{mas.}}$ [1 mark]

(ii) Plate scale:

$d\theta\,/\,dS = 1\,/\,f$ where f is focal length.

$d\theta \,/\, dS = 1 \,/\, 500$

$d\theta \,/\, dS = 0.002\,\mathrm{rads} \,/\, \mathrm{m}$

$d\theta \,/\, dS = 0.4'' \,/\, \mathrm{mm}$

$d\theta \,/\, dS = 0.4\,\mathrm{mas} \,/\, \mu\mathrm{m}.$

Therefore each 20μm pixel has an angular size of $8\,\mathrm{mas}$ (or equivalently an area of $64\,\mathrm{mas}^2$).

Area, A, subtended by star is approximately:

$A = \pi\,(\theta/2)^2$

$A = \pi \times (17.3/2)\,\mathrm{mas}^2$

$A = 235\,\mathrm{mas}^2.$

Therefore area subtended by star is approximately $235 \,/\, 64 \underline{= 3.7\ \text{pixels}}$. [2 marks]