McLean Sec9 Ex4&10

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4 Explain the concept of drift scanning. Why does it produce a good flat-field along the scan direction?

Drift scanning

・move charge of CCD at the same rate as stars move

・no star trails and wide area survey while the telescope is stationary

→・CCD charge pattern is transferred along columns while the image from the telescope is scanned

・average over the fixed pattern noise on the CCD

→reduce systematic errors to below 1% of the night-sky background level

10 Calculate the photon arrival rate for a 24th-magnitude star in the V-band on a 4 m telescope with a camera having an efficiency of 30%. Assuming that the pixels are 0.3 arcseconds, and the readout noise is 10 electrons, and dark current is negligible, is the measurement background-limited? What integration time is required to achieve a signal-to-noise ratio of 10?

Star magnitude m: 24mag in V-band
Telescope:
  Aperture D_{tel}: 4m
  Efficiency of camera $\tau\eta$: 30%
    τ:optical system efficiency, η:quantum efficiency of detector
  Pixel size θ_{pix}: 0.3''
  Readout noise R: $10e^{-}$
  Dark current: negligible

→area of telescope $A_{tel} = \pi(2m)^2 = 1.257 \times 10^5 cm^2$
  V-band: $\lambda = 0.54um, \Delta\lambda = 0.09um,$
$$F_\lambda(0) = 3.92 \times 10^{-12}\ W\ cm^{-2}\ um^{-1}$$

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- Power collected by telescope from a source

$$P(\lambda) = \tau(\lambda)\eta(\lambda)A_{tel}\Delta\lambda F_\lambda(0) \times 10^{-0.4m}$$

$$= 0.3 \times (1.257 \times 10^5\ cm^2) \times (0.09\ um) \times (3.92 \times 10^{-12}\ W\ cm^{-2}\ um^{-1}) \times 10^{-0.4\times 24}$$

$$= 3.34 \times 10^{-18}\ W$$

- photoelectron detection rate (photon arrival rate) from a source

$$S(\lambda) = P(\lambda)\frac{\lambda}{hc} = 3.34 \times 10^{-18} \times \frac{0.54\ um}{1.99 \times 10^{-19}\ J\ um}$$

$$= 9.1\ e^-/s$$

10 Calculate the photon arrival rate for a 24th-magnitude star in the V-band on a 4 m telescope with a camera having an efficiency of 30%. Assuming that the pixels are 0.3 arcseconds, and the readout noise is 10 electrons, and dark current is negligible, is the measurement background-limited? What integration time is required to achieve a signal-to-noise ratio of 10?

- Assume $m_{sky} = 21mag$, seeing 1" →$n_{pix} \approx 9$, flux of each pixel$\approx 1e^{-}/s$
- signal form the background in each pixel

$$B(\lambda) = \tau(\lambda)\eta(\lambda)A_{tel}\Delta\lambda F_{\lambda}(0) \times 10^{-0.4m_{sky}} \frac{\lambda}{hc}\theta_{pix}^2 = 12.9e^{-}/s$$

- integration time to become background limited

$$t > \frac{R^2}{B(\lambda)} = \frac{100}{12.9} = 7.8s$$

⇨background-limited

- integration time for S/N=10

$$\frac{S}{N} = \frac{S(\lambda)\sqrt{t}}{\sqrt{n_{pix} \times B(\lambda)}}$$

$$t = 140s$$