

Name \_\_\_\_\_ Due Date \_\_\_\_\_

## Astronomy 480 – Observing Preparation

01. Suppose you make an observation in which the total electrons received was 1000. If 400 of these were from the source, 400 from the sky, 150 from the dark current, and 50 from read noise, what is the S/N for this observation?

02. Suppose you make an observation in which the total electrons received was 100,000. If 400 of these were from the sky, 150 from the dark current, 50 from read noise, and the rest from the source, what is the S/N for this observation? Comment on your result from this problem to that of problem 1.

03. You need to make an observation that has less than a 5% error (meaning, you need a S/N of 20). If the flux from the source is 100 photons/second, the flux from the sky is 50 photons per second, and read noise and dark current are negligible, what is the minimum time you need to observe the source?

04. You need to make an observation that has less than a 1% error. If the flux from the source is 100 photons/second, the flux from the sky is 50 photons per second, and read noise and dark current are negligible, what is the minimum time you need to observe the source? Comment on your result from this problem from that in problem 3.

05. On a given night the seeing is 1 arc second (1"). Your CCD has a plate scale of 0.2" per mm, and pixels are 30 microns square. You are observing an isolated star with a total flux of 2500 photons per second. The sky has a brightness of 100 photons/sec/square". If dark and read noise are negligible, how long must you observe the star to obtain a S/N of 100?

Seeing = FWHM = 1"

Assume 99% of the flux falls within  $3\sigma = 3$  FWHM

- Translate the plate scale from arc seconds per mm to arc seconds per pixel:
- Find the FWHM in terms of pixels:
- Find the flux from the object per second:
- Find the number of pixels that the flux from the star will fall on (assume a circle):
- Find the flux from the sky:

06. You are working with a CCD with a gain of 4 e-/ADU. Within 25 pixels, you count a total of 15,000 ADU's. The sky has a typical value of 10 ADU/ pixel. The dark current is negligible, but there are 5 electrons of read noise per pixel. What is the signal-to-noise ratio for the observation of this star? Remember, all must be in electrons, and not ADU's.

A real problem and its solution:

Vega sets the magnitude scale at 0 mag. In the V band, we receive 23840 photons per second from Vega. HD209458 is a 7.65 magnitude star (V band) with an eclipsing giant planet on a 3.5-day period. The eclipse dims the light of HD209458 by 1.5%. What is the difference in flux between eclipse and no eclipse? What exposure time do you need in order to detect this transit at the  $2\sigma$  level? Consider the flux from the uneclipsed star when doing your calculations. Assume that the sky, read noise, and dark current are negligible.

$$\Delta m = -2.5 \log \frac{F_V}{F_{HD}} = -7.65$$

$$\frac{F_V}{F_{HD}} = 10^{\frac{7.65}{2.5}} ; F_V = 1148.15 F_{HD}$$

$$F_{HD} = \frac{23840 \text{ } \gamma/s}{1148.15} = 20.76 \text{ } \gamma/s \text{ (no eclipse)}$$

$$F_{HD}(\text{eclipse}) = 0.985 F_{HD} = 20.45 \text{ } \gamma/s$$

$$\therefore \Delta F = F_{HD}(\text{no eclipse}) - F_{HD}(\text{eclipse}) = 0.315 \text{ } \gamma/s$$

In order to detect the eclipse at  $2\sigma$ , the noise must be half of this.

$$\therefore \sigma_{HD} \leq \frac{1}{2} \Delta F = 0.158 \text{ } \gamma/s$$

$$S/N = \frac{F_{HD}(\text{no eclipse})}{\sigma_{HD}} = \frac{20.76 \text{ } \gamma/s}{0.158 \text{ } \gamma/s} = 131.7$$

and

$$S/N = \sqrt{F_{HD}(\text{no eclipse})t}$$

$$\therefore t = \frac{(S/N)^2}{F_{HD}} = \frac{131.7^2}{20.76 \text{ } \gamma/s} = 835.6 \text{ sec} \approx 14 \text{ minutes}$$