So the difference in signal through each filter is

$$N_A - N_B = 11,746 \ \frac{\text{photon}}{\text{s}}$$

Go to Step 1

Is this difference easy to detect? Use Poisson statistics. Jump back to Step 1 in lecture.

If one measures $N$ events which are generated independently via Poisson process (stars + photons are example), then

$$\text{uncert per measure} = \sqrt{N}$$

$$\text{fractional uncert} = \frac{\sqrt{N}}{N} = \frac{1}{\sqrt{N}}$$

In our case, each 1 second exposure collects

$$\text{on average} \quad \bar{N} = 9 \times 10^9 \ \frac{\text{photon}}{\text{s}}$$

but

$$\text{uncert} \quad \sqrt{N} = 94,868 \ \frac{\text{photon}}{\text{s}}$$

So

$$1\sigma = 94,868$$

$$\text{"signal"} = 11,746 = 0.12\sigma$$

Uh-oh. This difference is much smaller than the noise in the measurement. Trying to detect the atmosphere in this manner won't work unless we can find some way to improve the signal-to-noise ratio...

W10A

10/26/2026

Exoplanet atmospheres.

Start w/ Step 2: basic idea: atmos makes planet "bigger"

Work through example.

$R_S = 7 \times 10^8$ m

$R_p = R_E = 6.37 \times 10^6$ m

$h = 50$ km $= 5 \times 10^4$ m

1: solid body of planet blocks

$$f_{solid} = \left(\frac{R_p}{R_S}\right)^2 = 8.281 \times 10^{-5}$$

2. solid + atmos blocks

$$f_{solid+atmos} = \left(\frac{R_p + h}{R_S}\right)^2 = 8.41151 \times 10^{-5}$$

3. During transit, filter "A" = off-band

$$N_A = \text{flux} * \left[1 - f_{solid}\right]$$

$$= \left(9 \times 10^9 \frac{\text{photon}}{s}\right) * \left[1 - 8.281 \times 10^{-5}\right]$$

$$= 8,999,254,710 \text{ photon/s}$$

4. filter "B" = on-band

$$N_B = \left(9 \times 10^9 \frac{\text{photon}}{s}\right) * \left(1 - 8.41151 \times 10^{-5}\right]$$

$$= 8,999,242,964 \text{ photon/s}$$