

Astronomy 350, Autumn 2002, Problem Set 3

Due Thursday, October 24 in class

Problem 1

The following data are 30 observations of a 50 μ Curie sample of radioactive ^{137}Cs made using a Geiger-Müller Tube and a pulse counter. The units of the data are counts/30s.

24293	24934	24711	24520	24547	24668	24759	24717	24911	24754
24557	24543	24690	24684	24813	24693	24601	24336	24311	24848
24670	24510	24589	24787	24839	24617	24771	24746	24809	24792

- Compute the mean and standard deviation of the data.
- Compare your formal estimation of the sample standard deviation to the value you would predict assuming that the data follow a Poisson distribution.
- What fraction of data, f , lie within 1 standard deviation of the mean? Compare this to the predicted fraction assuming the data are normally (Gaussian) distributed (a good approximation of the Poisson distribution in the limit of large central values).
- Repeat parts (a) & (b) using only the first 10 observations in the table above. How does this affect the results for the standard deviation compared to the Poisson prediction?
- Comment on the value of acquiring more data in these kinds of problems. Are there any dangers in collecting too much data?

The data above are available from www.astronomy.ohio-state.edu/~pogge/Ast350/Data/ps3.dat

Problem 2

The diameter D and height H of a cylindrical water tank can be measured to a precision of about 1%. To what precision can you estimate the total volume of the tank, V ? Would it have been better to measure the tank's radius, R , to a precision of 1% instead of its diameter? Be quantitative in your assessment.

Problem 3

You are using a photon-counting photometer on a telescope. This instrument measures the number of photons that arrive in one minute.

First, you move a star into the entrance aperture of the photometer. The "signal" that you measure is the sum of the photons from the star plus the photons from the night-sky background falling inside the aperture at the same time. After 5 measurements, you have these numbers:

$$S = (\text{Star} + \text{Sky}) = \{1797, 1883, 1817, 1859, 1858\} \text{ photons/min}$$

You then move the telescope to point to an adjacent region of blank sky, and measure the number of photons that arrive each minute from just the background sky. After making 5 “background” measurements, you have these numbers:

$$B = (\text{Sky Only}) = \{1363, 1383, 1332, 1368, 1379\} \text{ photons/min}$$

Using these data, estimate the following:

- The mean photon counts/minute from the Star+Sky aperture (\bar{S}) and its uncertainty ($\sigma_{\bar{S}}$).
- The mean photon counts/minute from the Sky-only aperture (\bar{B}) and its uncertainty ($\sigma_{\bar{B}}$).
- The sky-subtracted star counts, $S_{star} \approx \bar{S} - \bar{B}$, in photons/minute, and its uncertainty.
- The ratio of the star’s counts to its uncertainty (i.e., the “Signal-to-Noise Ratio”).
- From the signal-to-noise ratio computed in part (d), would you conclude that this star was significantly detected against the bright background sky?