

PHY517 / AST443: Observational Techniques

Homework 3

1. Complete the homework assignments in Tutorial 4.
2. The Poisson distribution describes the probability to observe x events during a certain measurement interval, given a mean rate μ :

$$P_P(x|\mu) = \frac{\mu^x}{x!} e^{-\mu}$$

Note that x has to be a positive integer. Examples of where the Poisson distribution applies are counting experiments. In optical astronomy, we often *count* the number of electrons registered in the CCD due to incoming photons from a celestial object. The Poisson distribution is asymmetric for low rates $\mu \lesssim 10$, and becomes the Gaussian distribution for high rates $\mu > 1$.

- (a) Show that the mean of the Poisson distribution is μ .¹
 - (b) Show that the variance of the Poisson distribution is μ .
 - (c) Plot (on a single panel) the Poisson distribution for rates of $\mu = 1, 2, 4, 10$.
 - (d) For $\mu = 30$, plot the Poisson distribution, as well as a Gaussian distribution of mean $\mu = 30$. What do you need to set the standard deviation of the Gaussian to?
 - (e) You measured $N = 10,000$ electrons from a star. What is the uncertainty on this measurement?
3. For the following, consider the CCD sensor in our STL-1001E camera. When necessary, look up the relevant properties on its spec sheet.
 - (a) How many pixels would you expect to fall outside the 1σ interval for a random Gaussian process? How many for the 2σ , 3σ , 4σ , 5σ intervals? You can look up the corresponding integrals of the normal distribution at https://en.wikipedia.org/wiki/68%E2%80%939395%E2%80%939399.7_rule.
 - (b) **Bonus points:** Calculate the probability to have 0 pixels outside the 5σ range. Also calculate the probability for 1 pixels, and for 2 pixels.
 4. Again consider the STL-1001E camera, operated at 0°C . For what exposure times does the read noise dominate over the dark current?

¹Hint: the following series identity is useful for Exercise (1):

$$\sum_{k=0}^{\infty} \frac{\lambda^k}{k!} = e^\lambda$$

5. Read one of the papers you found about your "birthday object". Answer the following questions:
- (a) What purpose does the abstract serve? Is the result clearly stated? Does the abstract state anything that is not found in the paper itself?
 - (b) Where does a discussion of the existing literature go?
 - (c) Where do figure captions go? Where do table captions go? What goes into the captions? Is any figure or table not mentioned in the main text?
 - (d) Describe the purpose of the last section of the main text.
 - (e) In which part(s) are the results of the study stated?