ASTR 288C
Homework 8

Due: 3:30pm, Oct. 30, 2017

- In your home directory, create a directory on the ursa machine called `homework8_yourname`. Put all your codes in this directory.
- Name your code in this format: question1.py, question2.py...etc, where the 1 and 2 refer to the question number.
- The instructor will test run your code in order to grade it.
- **In all your code, write brief comments to describe each command/step in your code (similar to the comments in the example codes). This will be part of your grade.**
- **When printing your answers to the screen, need to include clear descriptions of what they are (i.e., not just numbers).**
- Email the full path of your homework directory to the instructor before the deadline.

1. [**10 points**] Comparing Poisson and Gaussian distributions. **Write one python code** to do the following:

   (a) [**2 points**] Create an array of randomly distributed numbers that follows a Poisson distribution with average $\mu = 100$ and a sample size $N = 10000$. Calculate the mean value μ and the standard deviation σ from your randomly generated number. Print your answers to the screen.

   (b) [**2 points**] Plot the histogram of this distribution.

   (c) [**3 points**] This Poisson distribution can be approximated by a Gaussian distribution with a certain mean and standard deviation. What is the expected values of the mean and standard deviation of this Gaussian distribution? Print these values to the screen. Also, print the expected mathematical relation between the mean and the standard deviation to the screen.

   (d) [**3 points**] Plot the Gaussian function with the mean and standard deviation you found in 1(c), on top of the Poisson distribution. Show the plot on the screen (this and the plot in 1(b) can be shown in one single plot).

2. [**5 points**] Assuming each exposure time in *Swift*/BAT image created for BAT trigger is about 10 sec. BAT will trigger a GRB if the signal-to-noise ratio is above 6.5. What is the expected number of BAT's triggers that are false detections in a year? Print your answer to the screen.

3. [**12 points**] The binary neutron-star merger event, GW170817, was recently detected by LIGO and many observatories that covers a wide range of wavelengths. The BAT raw light curve around the trigger time of this event can be found at `/n/ursa/A288C/alien/python_template/GW170817_1s_rate_sort.lc`. Download this light curve and **write one python code** to do the following questions. The trigger time of the gravitational waves detection (T0) is 524666483.999 s [MET].

   (a) [**2 points**] Calculate the average and standard deviation for data within the duration from T0-100 s to T0+100 s. Print your answer to the screen.

   (b) [**2 points**] Plot a histogram of the counts in the above duration. Also, plot the Gaussian function using the average and standard deviation you calculated. Show your plot on the screen.

   (c) [**2 points**] Calculate the expected false-detection rate for detection $\geq 3\sigma$ based on this Gaussian function. Print your answer to the screen.

   (d) [**2 points**] From the false-detection rate you calculated, how many detections that are $\geq 3\sigma$ do you expect to find in this data set (from T0-100 s to T0+100 s)? Print your answer to the screen.

   (e) [**2 points**] Now search for the actual detections that are $\geq 3\sigma$ in this data set, how many detections do you find. Print your answer to the screen.

   (f) [**2 points**] Based on statistical properties for the photon counting instruments (like the BAT), estimate the standard deviation from the average number you calculated from 3(a). Is the expected standard deviation close to the actual number that you calculated? If there are any differences, what could be the reasons that explain the differences? Print your answer to the screen.

4. [**10 points**] For XRT detections, usually we have very low number of counts and thus the Gaussian approximation is no longer valid. Assuming you detect 5 background photons in the XRT image, use the Poisson distribution to find out how many counts you need to detect a source in order to make sure the false-detection rate is lower than 1.0×10^{-10}? Print your answer to the screen.