Problem Set 3
PHY670: Astro Statistics
August - November 2025
IISER Mohali

1. Supernovae occur at a rate of approximately once in 50 years in a Milky way type galaxy. Model the galaxy as a two dimensional exponential disk: surface density of stars scales as $\exp(-r_s)$ with scale radius $r_s = 3$ kpc and an outer radius of $5r_s$. Generate a sequence of uniformly distributed supernovae (in time) with probability of location proportional to the surface density of stars in the disk. This should be done for a time period of ten million years. Now place 1000 observers randomly in the disk and compute the distribution of time between successive supernovae for these observers, taking into account the light travel time. Compute the following:

   - Average time between observation of two successive supernovae for an observer. This should be computed by averaging over the sequence of supernovae and observers.
   - Standard deviation for the same.
   - Median and quartile distribution for the same.
   - If we compute the cumulative PDF, what is the time between successive supernovae observed by an observer for $cpdf = 0.05$ and $cpdf = 0.95$?

2. Generate a white noise Gaussian Random Field (GRF) in one dimension with 2^{20} elements. Do the following:

   - Compute and plot the distribution of gaps between successive zeros of the GRF.
   - Compute and plot the distribution of local maxima (heights) of the GRF.
   - Compute and plot the distribution of gaps between successive local maxima of the GRF.
   - Repeat the last step for local maxima with heights more than the average height, and also for local maxima with heights more than the average plus standard deviation.