For this laboratory, a plot and a GIF were created to demonstrate the relation between the surface brightness fluctuations and the distance of a galaxy. Our goal was to prove that there is a proportional relation between the inverse of the distance to a galaxy and the relative variance of the measured flux.

We created 3 functions to prove this. The first one creates random star positions in a 2d coordinate system distributed on an assigned number of squared pixels. The second function takes the stars’ random positions and sorts them into a 2d histogram (2d array) containing the bin information, meaning how many stars there are per bin.

We challenge the standard simulation by replicating variations in the stars’ luminosity. To make the simulation more realistic, we assign we scale each star’s flux by a random Gaussian distributed factor. In reality, stars have different luminosities based on their spectral type and stage of their evolution. We assume that the luminosities are approximately Gaussian distributed.

Finally, the third function computes the flux’s standard deviation, i.e., the relative difference between the number of stars (weighted with their brightness) of each defined square pixels. The distance is defined as the square root of the number of stars. We present the geometric derivation in the PDF file present in the directory “geometric\_calculations\_distance.pdf”. The inverse of the distance over the flux variance was then plotted with all the data. A linear fit was provided to demonstrate the proportional behavior.

To visually demonstrate the inverse relationship of the distance and the variation in flux, we create a gif of fluxes on a grid with an increasing number of stars. We achieve this by iteratively creating plots, saving them, and finally combining them into a gif. The gif can be found in the Lab3 folder and is called “animation.gif”. Initially, there is a large visible variation between the pixels, but as the number of stars increases (recall, distance = sqrt(number of stars)), the pixels look more uniform.

Finally, to make the code more realistic, the number of pixels could be increased. Ideally, the flux of each star would be measured. Also, some assumptions were made that make the code less realistic. It was approximated that all stars are being equally far away in a galaxy. We assume a completely random distribution of the star positions within a galaxy, i.e., that the surface density within a galaxy is constant. Making a code that takes these factors into consideration would make the simulation more realistic. For example, adding a surface density function for stars (instead of true randomness) based on observations would be a good step. Also, using real data as a reference to calibrate our simulation would make it far more realistic. This could include not only real star positions but real fluxes measurements as well.

Note that we use relative fluxes for our image plots (not scatter plot with the fit). We represent flux by color, and our colormap function automatically normalizes the fluxes.