Astronomy 330 Class 5 Exercise

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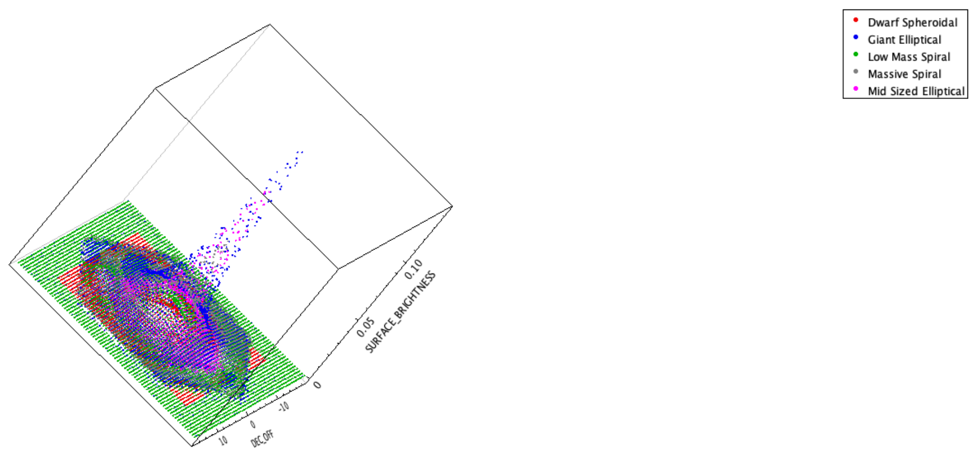
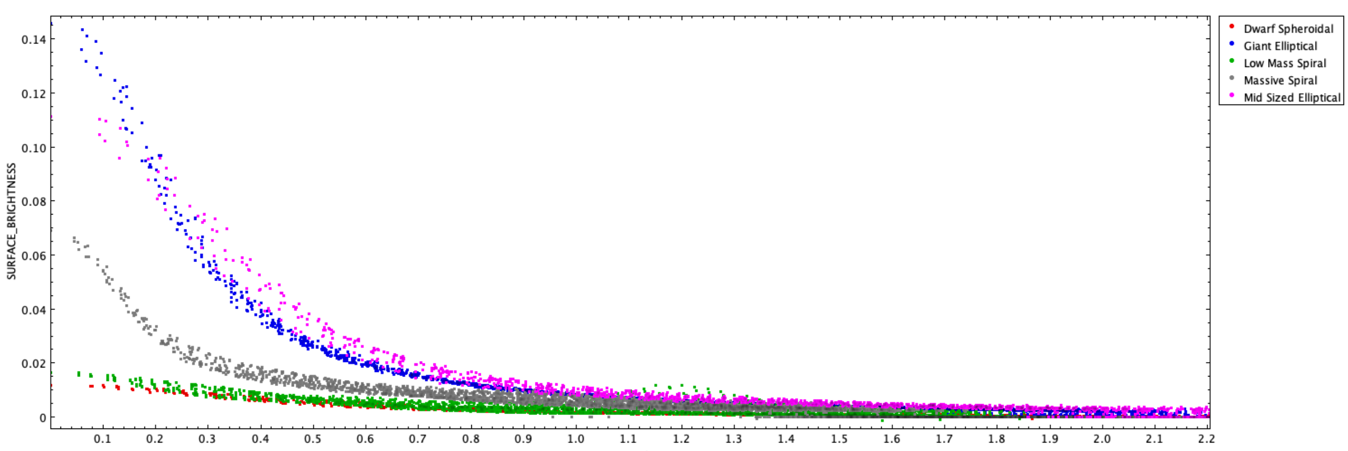
1. This is for question 2 of the exercise: Initially when I plot the 3D plots, there are a lot of differences between the 5 galaxies. The dwarf spheroidal galaxy has a lowest surface brightness as compared to all the other galaxies. The giant elliptical galaxy has the highest surface brightness compared to everything else. The low mass spiral galaxy has its surface brightness more spread out while other galaxies have most of their surface brightness concentrated at the center of the galaxy. This can be confirmed by seeing the images of the galaxies provided on page 3 of the assignment. This is how my 3D plot with all the galaxies looks like, scaled properly:

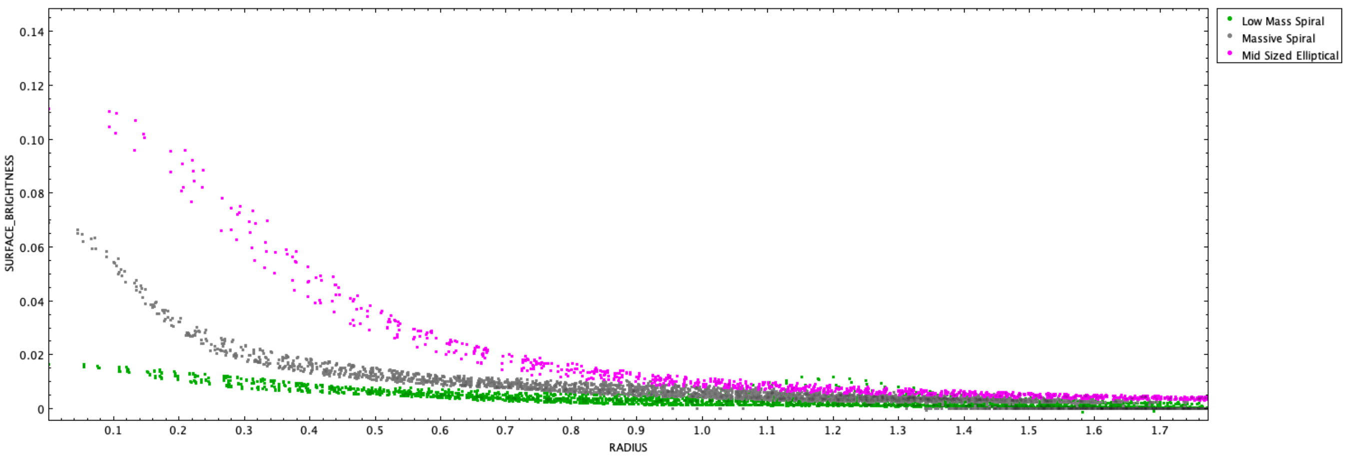


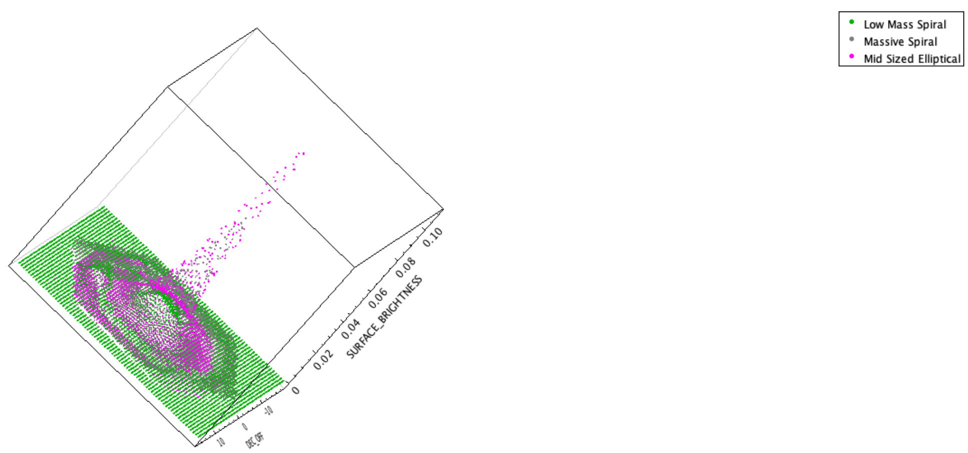
2. This is for question 3 of the exercise: The trend I saw in the 3D plot is prevalent in this plot as well. Here is how the 2D plot looks like with all the galaxies:



3. Question 4 (a): Does the massive spiral more closely resemble the low-mass spiral or the mid-sized elliptical? Why do you think that is?

   The massive spiral better compares/resembles with mid-sized elliptical than the low mass spiral galaxy for both the 2D and 3D plots. Here they are:





   The mid-sized elliptical has the highest surface brightness out if the three. The massive spiral galaxy is following mid-sized elliptical galaxy's trend more closely than the low mass spiral galaxy. The decrease in surface brightness for the mid-sized elliptical and massive spiral appears to be similar as if the massive spiral is a scaled down version of the mid sized elliptical. Also, the evenly distributed surface brightness seen in the low mass spiral is not there in the massive spiral.

4. Question 4 (b): In what way does the dwarf spheroidal differ from the other early-type galaxies?

   From what I can identify, giant elliptical and mid-sized elliptical are the other early-type galaxies along with the dwarf spheroidal. When you compare these three side by side, both the elliptical galaxies follow the trend of having very high surface brightness at the center which exponentially decreases as you go away from it. The dwarf spheroidal also follows the same trend, but it's much more scaled down as compared to the other two. This is how all of them look like:

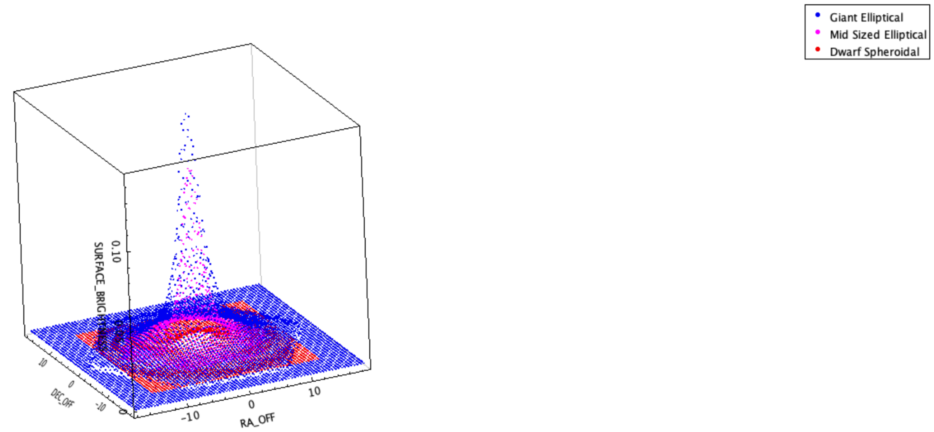


Figure 1: 3D plot showing the three galaxies

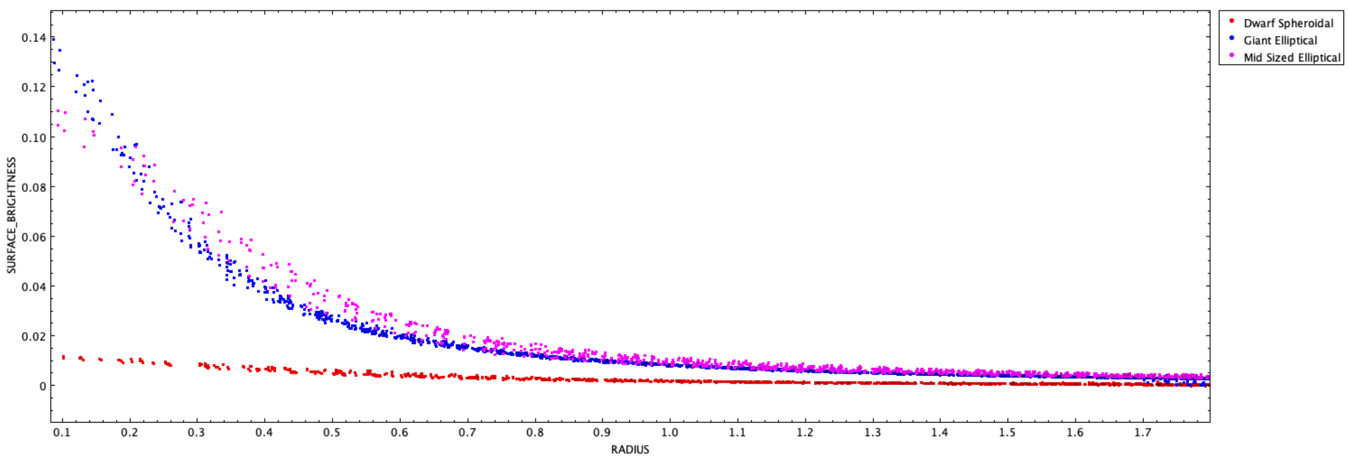


Figure 2: 2D plot showing the three galaxies, how they compare and scale

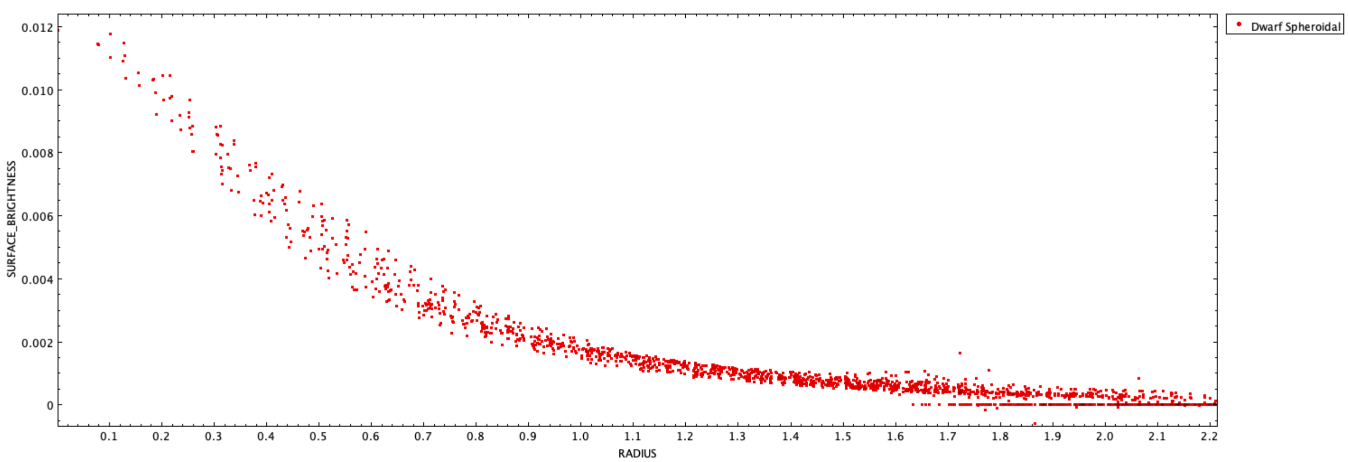
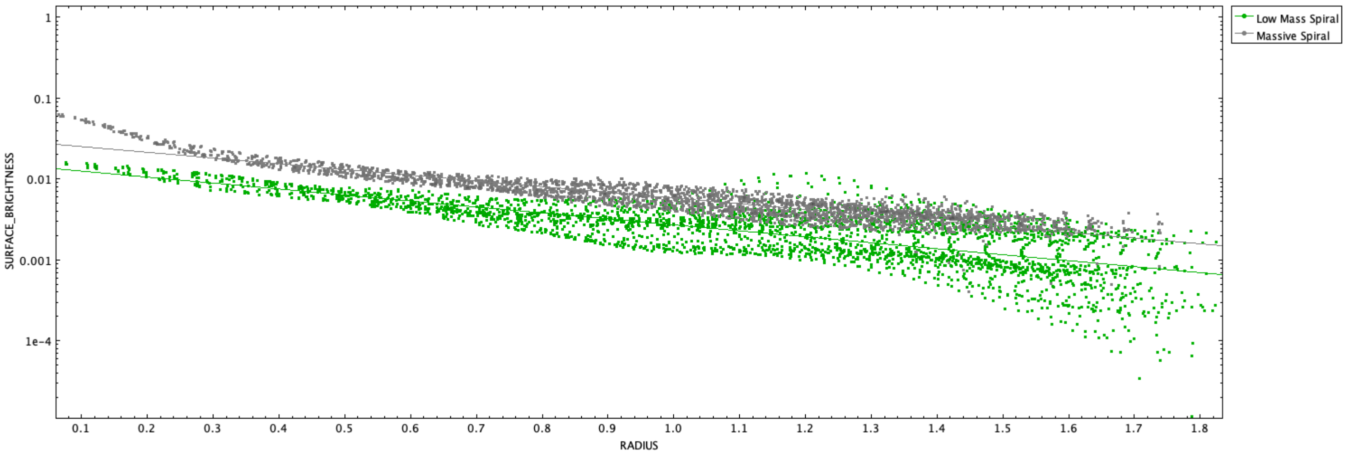


Figure 3: Only the dwarf spheroidal galaxy to see how it's surface brightness varies with radius.



If you see Figure 2, you can't see the similar trend of decreasing surface brightness, but you can clearly see it if you look at Figure 2 and 3 simultaneously. Also, you can see that all three of them have high brightness near the bulge and it decreases as you go away from the center. They also have similar disk radius. In conclusion, the only difference I see is with the amount of surface brightness dwarf spheroidal has compared to the early-type galaxies.

5. Question 4 (c): Now change the y-axis to be log-scaled (click on the Axes icon) and compare the two spirals. The expected light profile of a spiral is $I(r) = I_0 e^{-r/r_h}$. Thus, taking the log of the flux should produce a light profile that is linear with radius. Is that what you see? Why might there be deviations?

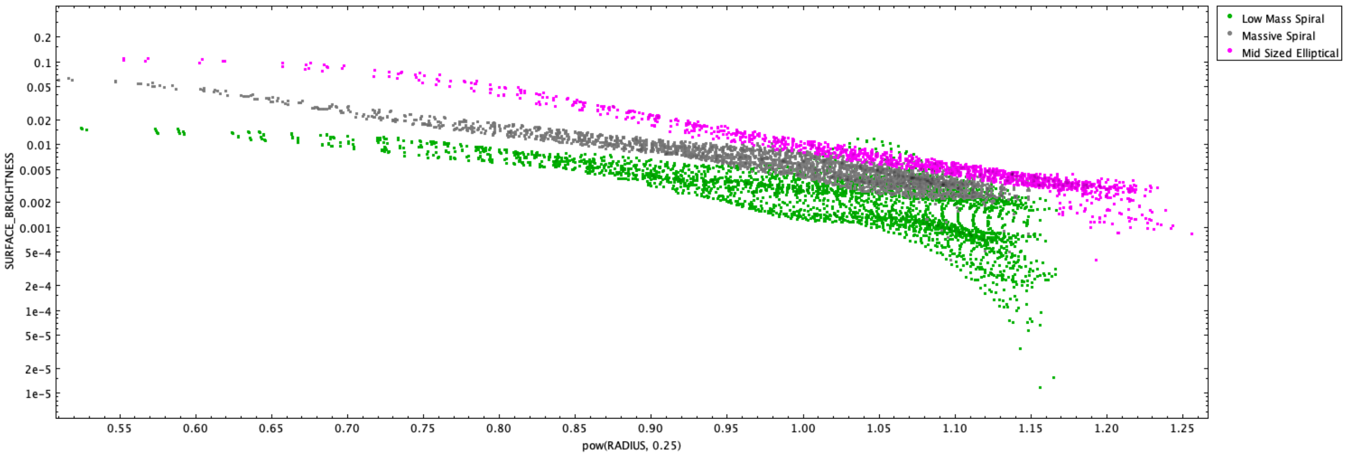
   Yes, after making the y-axis log scale, I do see kind of a linear decreasing trend as a function of radius along with a few deviations as you reach the edge of the galaxy disk. Many spirals have a central bulge whose brightness profile is steeper than the disk's flux, causing the inner data points to deviate from the simple exponential trend. Localized star formation in the arms and dust attenuation can cause bumps in the radial profile when you look at individual pixels. At larger radii, the disk can taper off faster than a pure exponential, and the signal can below low, causing the measurement to scatter. This is how the plot looks like:

6. Optional: Ellipticals generally have light profiles described by de Vaucouleurs Law (below). These light profiles will be straight lines when the y-axis (flux) is log scaled and the x-axis is $R^{1/4}$. To make this change, set X: pow(RADIUS, 0.25). Do the early-types behave as expected? What observational effects might we need to worry about in the galaxy's core?

   $$I(R) = I_e e^{-7.669[(R/R_e)^{1/4}-1]}$$

   In the $log(I)$ vs. $R^{1/4}$ plot for the elliptical galaxies, you can see that the giant and mid-sized ellipticals come close to forming straight-line profiles, while the dwarf spheroidal deviates more. Near the center, the data often flattens or scatters due to observing limitations (like seeing or dust), and at larger radii there can also be deviations from a simple trend. Overall, the general shape is roughly what you would expect for de Vaucouleurs-type profiles, but real galaxies rarely match perfectly because of these practical effects.

1. A plot of surface brightness vs. radius for the two spiral and the mid-sized elliptical. Use log scalling for Y and include a legend.



2. A plot of surface brightness vs. radius for the two elliptical and the dwarf spheroidal. Use log scalling for Y and include a legend.