Surface Brightness Profiles of Spiral and Elliptical Galaxies

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Introduction

In this project, we wanted to create **surface brightness profiles** of a few spiral and elliptical galaxies, observing how their brightness decreased as a function of distance from the galactic center.

We were interested to see whether data we collected on spiral galaxies M74, NGC 6946, and NGC 7331, and elliptical galaxy NGC 205 would match up with how we expected the brightness to change based on known functions for these types of galaxies.

What’s The Difference?

M74

NGC 205

Spiral galaxies are like our own Milky Way: they have a bulge in the center and a disk that contains the curving arms of the spiral.

Their surface brightness profiles can be described by exponential disk functions:

$$I(R) = I(0)\ e^{-R/h_R}$$

Elliptical galaxies are like the bulge of a spiral with no disk.

Their surface brightness profiles can be described by Sersic bulge functions:

$$I(R) = I(0)\ e^{-kR^{1/4}}$$

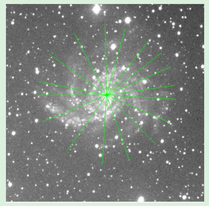
Methods

Total Exposure Length per Filter (minutes)			
Galaxy	B Filter	V Filter	R Filter
NGC 7331	160	40	80
NGC 6946	110	75	75
M74	40	36	36
NGC 205	30	15	37

We observed and collected data in B, V, and R (blue, visible, and red) filters over multiple nights on Whitin Observatory’s 24 inch telescope and CCD camera.
We used AstroImageJ to correct the images for extra noise and to find the center of our galaxies. We then used DS9 to take “cuts” and Python to analyze the collected data.

How To Make A Surface Brightness Profile

Image of NGC 6946

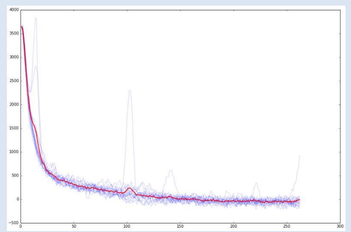


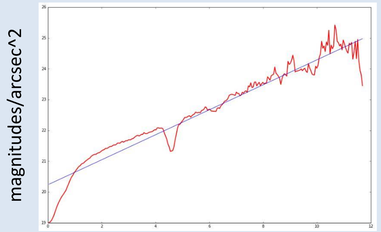
NGC 6946 with “cuts” taken along several radii

Excel spreadsheet containing data from all the cuts

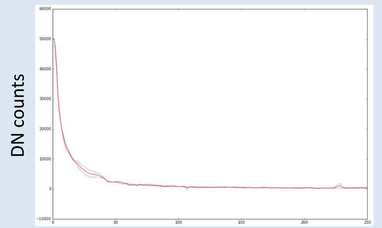
Python plots to interpret the data and see if the brightness changes as we expect!

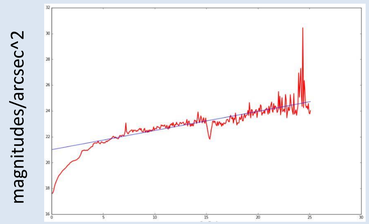
M74



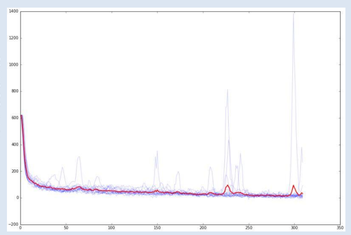


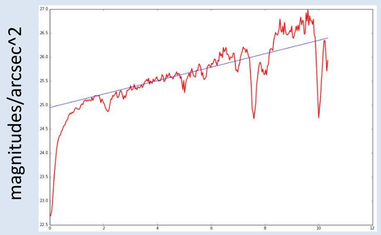
NGC 7331



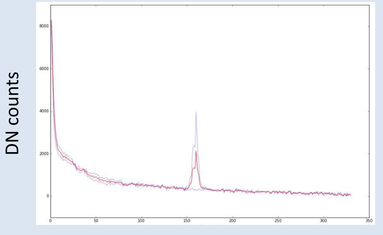


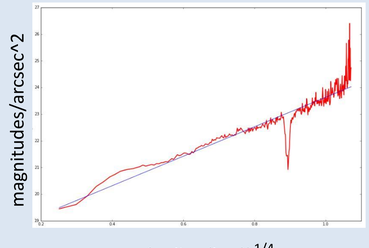
NGC 6946





NGC 205





For each of the galaxies above, the left plot shows all of the cuts taken (with the red line indicating the average of all the cuts).
The right plot converts the brightness into magnitudes per square arcsecond and the radii into kiloparsecs and plots a best fit line for the data.

Discussion

We found that the data from all four galaxies we observed fit the patterns that we expected. M74, NGC 6946, and NGC 7331 all fit the exponential disk function, with linear relationships between the calculated magnitudes (which are logarithmic) and the radius. NGC 205 fit the Sersic bulge function, with a linear relationship between the radius raised to the power of .25 and the calculated magnitudes.
This matches the broader understanding that the surface brightness of elliptical galaxies is more uniform and slower to decrease compared to the more localized and rapidly decreasing surface brightness of spirals.

References

CCD information courtesy of:
http://www.aavso.org/sites/default/files/CCD_Manual_2011_revised.pdf
Photometry information courtesy of:
http://www.aavso.org/sites/default/files/publications_files/ccd_photometry_guide/CCDPhotometryGuide.pdf
Surface brightness profile information courtesy of:
http://www.faulkes-telescope.com/files/faulkes-telescope.com/archive/projects/galaxies/bright_profiles/ds9_profiles.pdf
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