Observation and Analysis of the Blue Snowball Nebula

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Introduction

For my practicum project, I served on an observation team which photographed and analyzed planetary nebula NGC 7662, also known as the Blue Snowball Nebula. The project was organized through ASTR 310 – Observational Astronomy – which is a core class for all UMD astronomy majors taken during the fall semester. As a team, we hypothesized that the nebula would appear both brighter and larger in the Sloan g' filter when compared to the Sloan i' filter, both of which limit the possible wavelengths recorded by the telescope we used for capturing images. In order to validate our hypothesis, we recorded images of NGC 7662 at the College Park Observatory and analyzed our data in MATLAB. Our research not only provided useful information about NGC 7662, but planetary nebulae as a whole and their unique stellar properties.

Data & Analysis

While at the observatory, we recorded four types of images with a 14-inch Celestron telescope: science, dark, bias, and flat. In short, science images were photographs specifically of NGC 7662, bias images were photographs taken with the shutter closed and a zero second exposure time, dark images were identical to the bias images except for the exposure time, which was increased to match the exposure time of the science images, and flat images were photographs of a uniformly lit surface taken through the same two filters used to capture the science images. The bias, dark, and flat images were all used to calibrate the initial science images and eliminate both additive and multiplicative noise created by the telescope and recording equipment. After the initial science images had been properly calibrated, final images were created by combining each calibrated image based on the filter it was recorded through. The final images of NGC 7662 can be seen in figures 1 & 2, to the right.

Once the final images of NGC 7662 were produced for the i' and g' filters, we performed two types of analyses: flux mapping, and aperture photometry. These two procedures allowed our team to determine both the size and brightness of NGC 7662 quantitatively as opposed to a strictly visual approach. The first technique, flux mapping, was used to determine the edge-to-edge size of the nebula in both the horizontal and vertical directions. By using the MATLAB command 'improfile', I was able to draw horizonal and vertical lines through the center of each image and record the flux value for every pixel covered by a line that I drew. The flux profile in the horizontal direction through the Sloan i' filter can be seen in figure 3, to the right. Once each profile had been graphed, the mean and standard deviation (sigma) in the flux values of the sky surrounding the nebula was found. I looked for the intersection between each flux profile and the mean plus the standard deviation multiplied by four, as a four-sigma measurement ensured that the flux values recorded through the mapping process were in fact caused by the nebula and not any type of background noise or error. Once the horizontal and vertical size of NGC 7662 was found for each filter, the total brightness of the nebula could be determined through aperture photometry. With the radii found from the previous flux mapping, I used a MATLAB script provided by the UMD Astronomy Department titled 'aperE.m'. This program used the radius of the nebula along with two larger radii in order to subtract the average flux value of the background sky from the flux value of each pixel inside nebula's radii.

Figures & Images

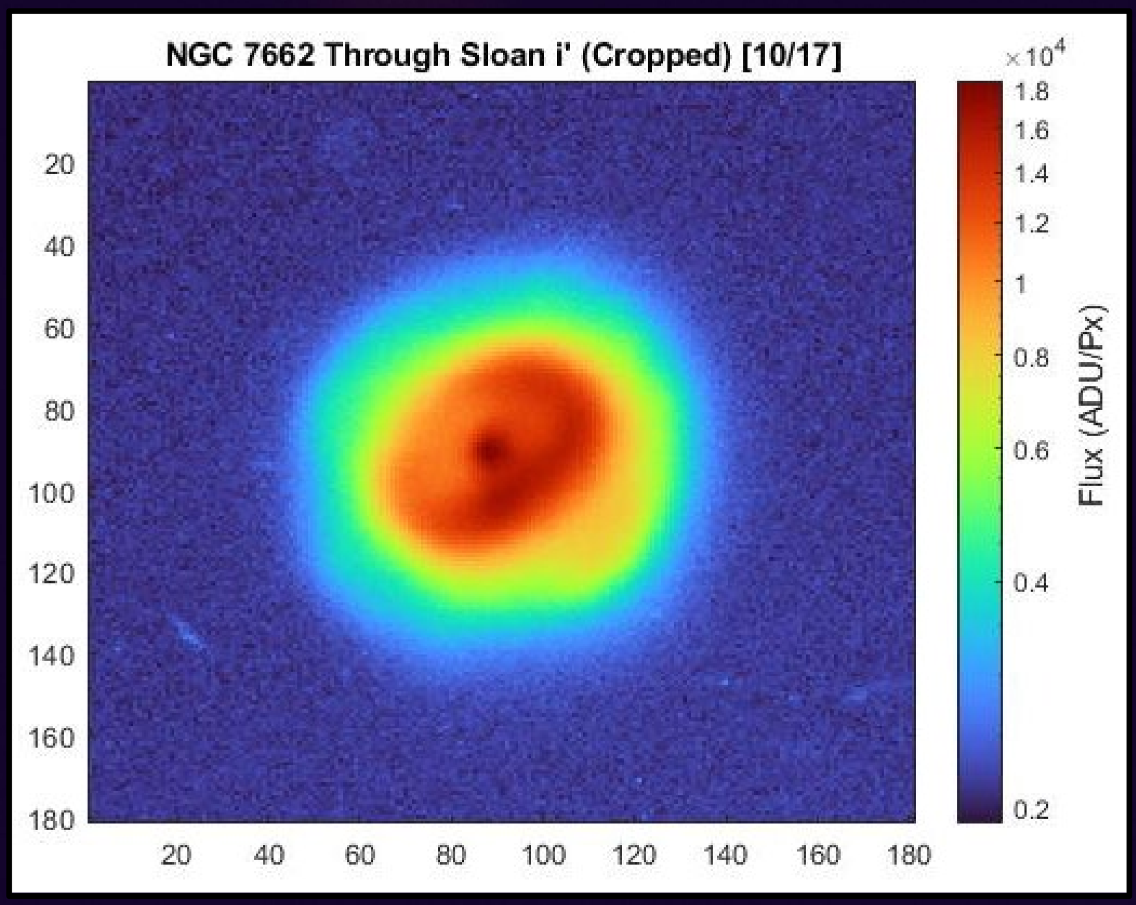

Figure 1: NGC 7662 as viewed through the Sloan i' filter

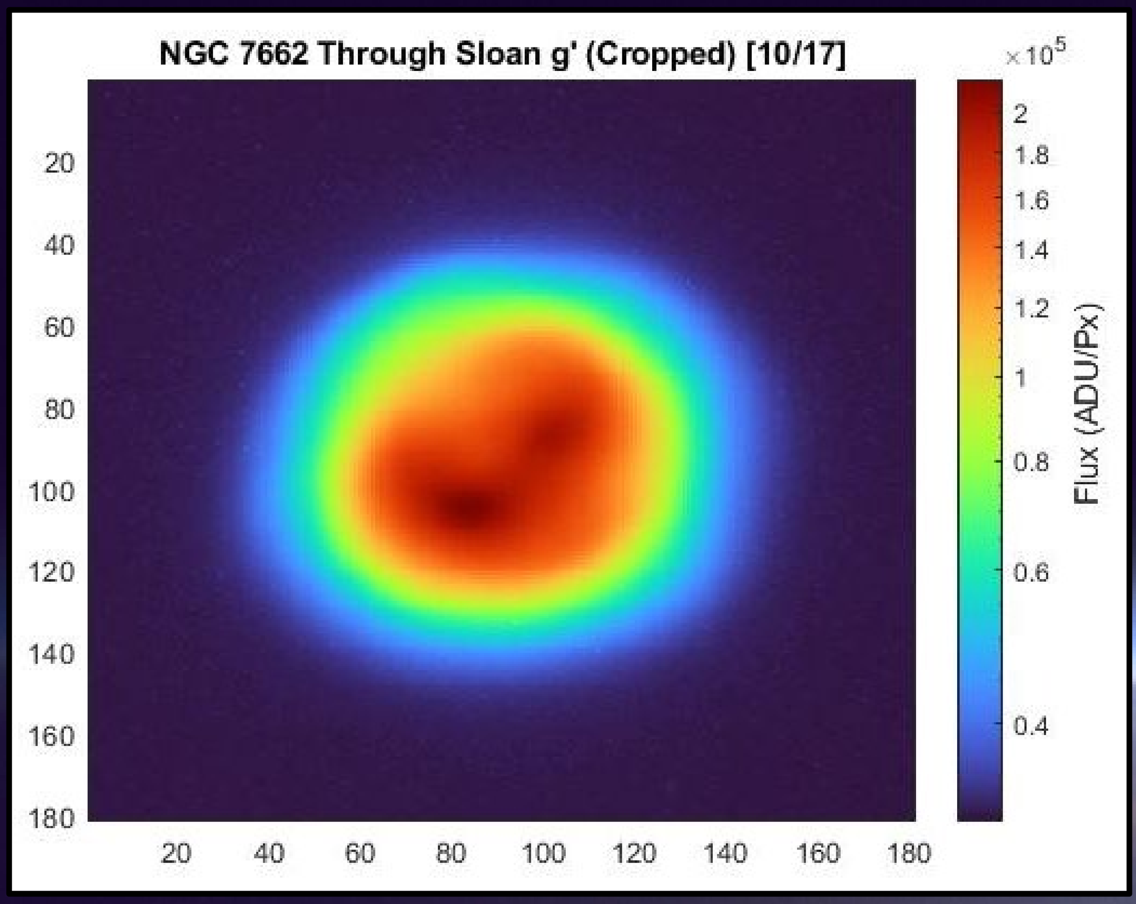

Figure 2: NGC 7662 as viewed through the Sloan g' filter

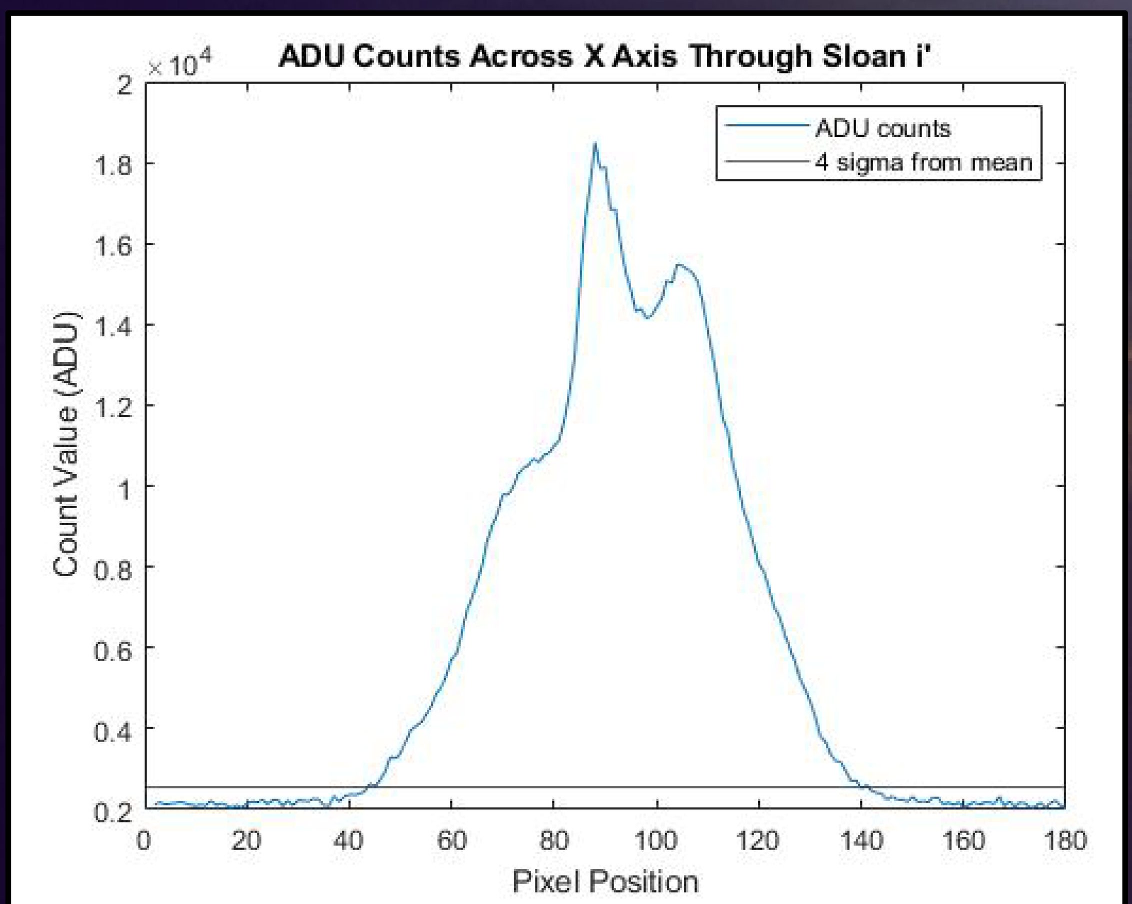

Figure 3: The horizontal flux profile for NGC 7662 through the Sloan i' filter.

An image of myself analyzing and processing data in MATLAB

Results & Uncertainty

Once both flux mapping and aperture photometry had been completed, the results from each process had to be interpreted and compared to our original hypothesis. Based on the results recorded in tables 1 & 2, below, NGC 7662 was both brighter and larger when viewed through the Sloan g' filter as compared to the Sloan i' filter. We believed this to be the case for a couple of reasons, the primary one being the emission of what are known as "forbidden spectral lines". The rarefied atmosphere surrounding planetary nebulae allows for certain wavelengths of visible light to be emitted that could not be found on earth. One of these wavelengths is produced by doubly-ionized Oxygen and corresponds to a strong shade of green. The g' filter allowed for the penetration of this special green light, while the i' filter did not.

Filter	Axis	Diameter (Px)
i'	Y	107 ± 3.6
g'	Y	111 ± 2.0
i'	X	99 ± 1.5
g'	X	118 ± 2.0

Table 1: The horizontal and vertical diameters of NGC 7662 through both the i' and g' filters found through flux mapping.

Filter	Flux (e/Px)	Uncertainty (e/Px)
i'	$2.75 * 10^7$	$5.66 * 10^5$
g'	$7.82 * 10^8$	$3.24 * 10^6$

Table 2: The brightness of NGC 7662 through both the i' and g' filters found through aperture photometry.

Acknowledgements

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The final paper can be viewed at the link below:
https://docs.google.com/document/d/1rKm5zwT146VDV6A31Y_egv0t3_xQCiQzrjvmJ_1lXsA/edit?usp=sharing

Citations & Sources

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