# Processing Images from the Hubble Space Telescope and McDonald Observatory


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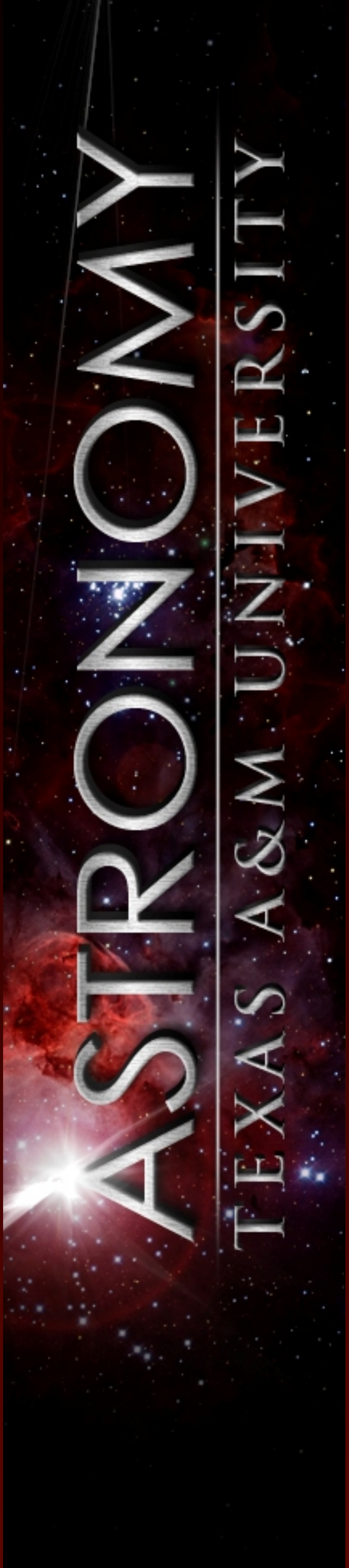



## Abstract

We measure the brightness and colors of distant galaxies with imaging taken by the Hubble Space Telescope (HST). In order to use this data for analysis, the raw imaging data are corrected for cosmic ray contamination, astrometrically aligned, and combined in the three different filters that we use. With images in these filters, we generate Red-Green-Blue (RGB) color images and measure and catalog the fluxes for thousands of objects which can be used for more data analysis. Our method can be generalized to imaging from any telescope. To demonstrate, we also reduced imaging and produced a colored image of the Omega Nebula of Sagittarius in the Milky Way that was taken with the McDonald 0.8m telescope.


## Introduction

In this project, we use imaging taken by the HST to measure the brightness and colors of distant galaxies. Since they are so distant, the raw imaging data must be prepared in order for it to be used for further analysis. To do this we use several programs from a package called DrizzlePac to correct the cosmic ray contamination, astrometrically align each image, and then combine the images of the three different filters that we use. Afterwards, we are able to use these images to generate a RGB colored image and even catalog and measure the fluxes of the objects in these images using another program called Source Extractor (SExtractor). During this time, we also managed to test our method with images from another telescope from the McDonald Observatory. Here, I took images of the Omega Nebula in three different filters and was able to use this method in order to generate an RGB image.

## Hubble Space Telescope Images

For the images that we obtained from the HST, we obtained them from an imaging instrument installed called the Wide Field Camera 3 (WFC3). We used three filters for these images: 105W (blue filter), 125W (green filter), and 160W (red filter). Each filter had a set of eight images. The reason we use many images is because they are taken at different orientations, which reduces instrumental errors. We used different filters in order to obtain data from different wavelengths, which lets us know different properties of the objects in the images.

Figure 1: One of the two fields of view (FOV1) that we obtained from HST in the 160W. This is a comparison between the original (left) and the final drizzled image (right)

## Preparation of Images

In Python, we are able to use a package called DrizzlePac which uses several methods that are relevant to the preparation of the HST images for analysis. These methods are Astrodrizzle (AD), Tweakreg (TR), and Tweakback (TB).

Methodology

1) Astrodrizzle (default settings) to generate cosmic ray clean images (crclean)
2) Tweakreg to astrometrically align headers of crclean images. It only aligns the headers, not the images.
3) Tweakback to astrometrically align the original images with the information in the WCS of the crclean images, which is found in the header.
4) Astrodrizzle to correct cosmic ray contamination on the images that are now correctly aligned.
5) All the "clean" input images are "drizzled" together to generate a single final drizzled image
6) Obtain the final drizzled image for each filter

## RGB Color Images

After we make the final drizzled image, we are also able to do an RGB Color image with it. What you do is that you take the three final drizzled image of each filter and you stack them together using ds9. After that you move the scale parameters around until you find a a balance between all three, resulting in a colored image.

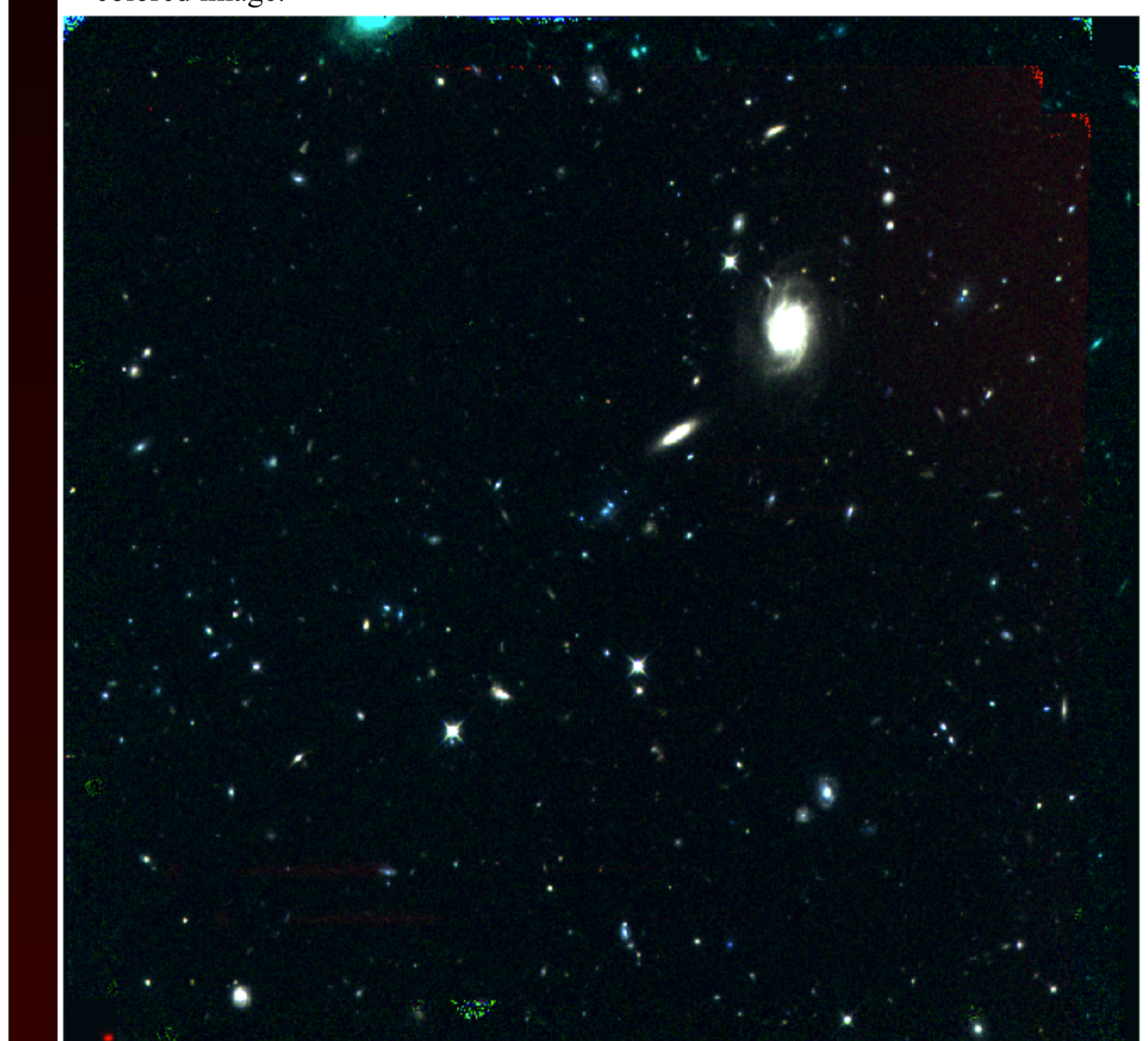

Figure 2: Final colored image of FOV1

## Detection of Objects

For the detection of objects in the final drizzled image, we use another program called SExtractor or Source Extractor (SE).

Methodology in SE

1) Determines whether pixels belong to background or objects by setting a certain threshold.
2) In dual image mode, one image is used to get the positions of the sources while in the other you get your photometry values
3) Splits up areas that are not background into separate objects.
4) Determines properties of each object.
5) Generates photo apertures to detect changes in the flux in the sources found in different arc seconds.
6) Writes this information in a catalog.

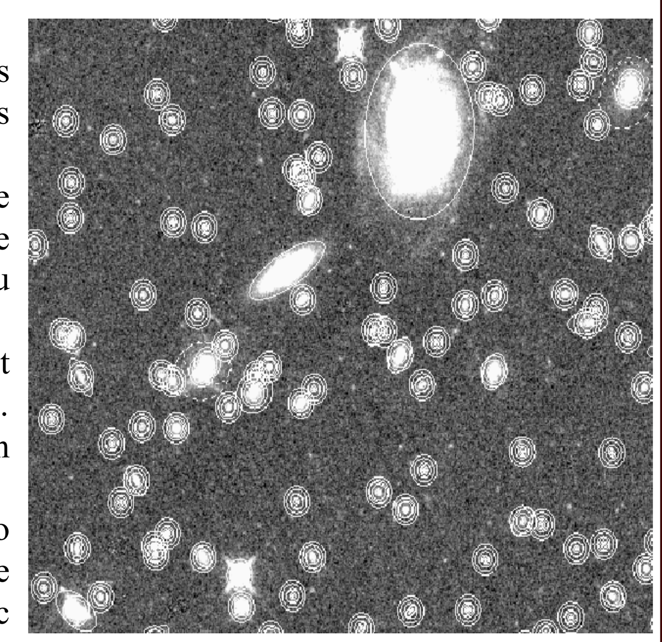

Figure 3: Photo apertures image of FOV1 in 160W

## Curves of Growth

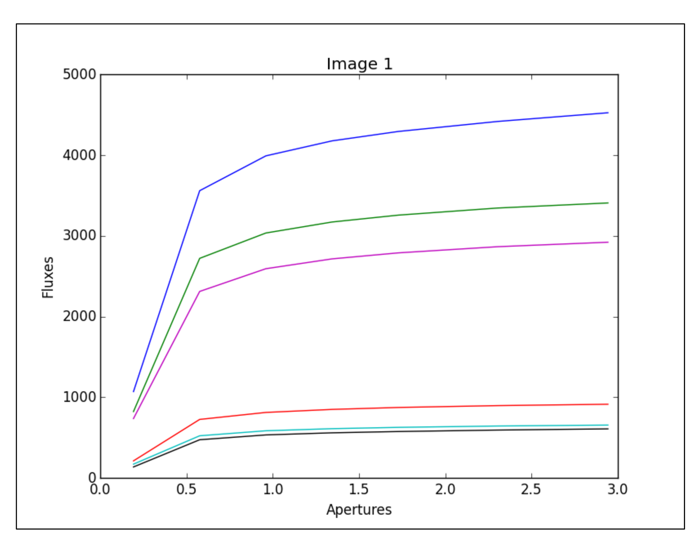


Figure 4: Curve of Growth of FOV1

After running SE, we are also able to generate curves of growth, which are plots showing the increment in the flux of the sources depending on the apertures that we had chosen before. We are able to pick out the fluxes from the catalog files of each source that we want. Afterwards, we are able to generate a PSF for the image, and it is ready to be used for analysis.

## McDonald 0.8m Telescope Images

Figure 5: One of the images I took in the R filter of the Omega Nebula

In the McDonald Observatory, I used the 0.8m telescope to take pictures of the Omega Nebula in Sagittarius at night. Afterwards I used Astrometry.net in order to obtain a WCS for these images in order for them to go through the method used for the HST images.

Filters used: Red, Visual (Green), Blue

Images per filter: 4

Exposure time: 10 seconds

After we obtained the pictures of the Omega Nebula from the McDonald observatory, we separated them by filters: B, V, and R. Afterwards, we went through the same process mentioned here and managed to generate an RGB image of it.

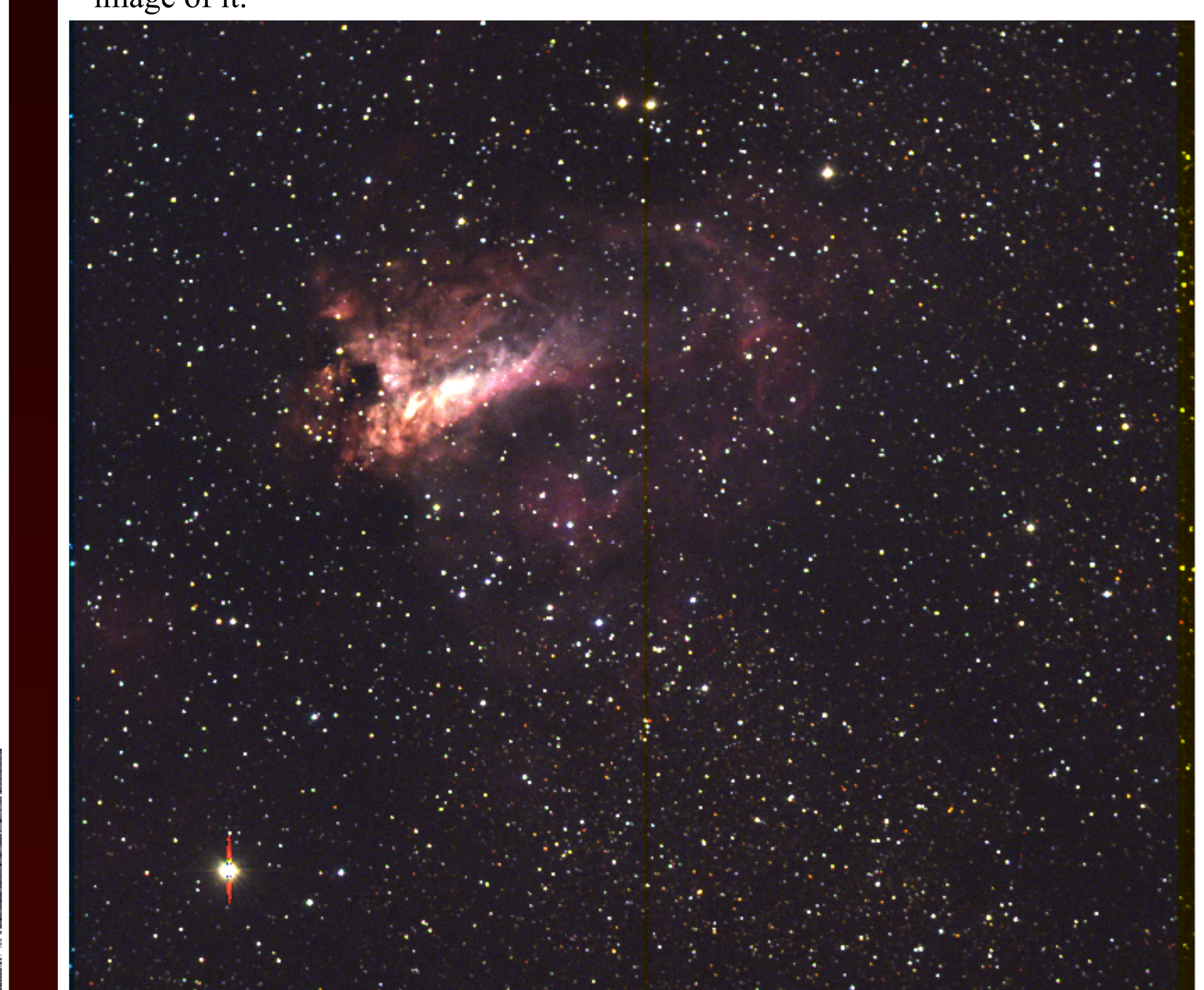

Figure 6: Final colored image of the Omega Nebula

Figure 7: REU students at the McDonald Observatory

## Conclusions

We presented a methodology to take images taken by the HST that enables us to measure brightness and colors of distant galaxies. With it, we are able to take raw data and remove cosmic ray contamination and astrometrically align it using DrizzlePac. Afterwards, we are able to generate catalogs of the sources found in the images using SExtractor and even generate RGB images using ds9. We are able to further analyze these distant galaxies to learn more about them and their properties and even use this method in pictures of other objects.

## References


Holwerda, Benne W. "Source Extractor for Dummies." ASTROPHYSICS at METU. Space Telescope Science Institute, 2008. 1 July 2015. <http://astroa.physics.metu.edu.tr/>


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## Acknowledgments

This work was supported by NSF grant AST-1263034, "REU Site: Astronomical Research and Instrumentation at Texas A&M University. I also would like to thank the undergraduates and grad students Leo Alcorn, Ben Forrest and Adam Tomczak who supported me throughout the project.