High Energy AstroPhysics Assignment

Generating Images in Bulk using the NASA SkyView

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Abstract

In this assignment, we harness the power of well-established Python libraries, such as Astropy and Astroquery, to embark on a journey through the cosmos. Our mission: to capture and analyze the elusive beauty of distinct galaxies. We will not only acquire breathtaking images but also delve into the physical characteristics of these celestial wonders. Our arsenal comprises seven exceptional surveys from the NASA SkyView repository: **DSS2 Red**, **DSS2 Blue**, **DSS2 IR**, **WISE 22**, **GALEX Near UV**, **NVSS**, and **TGSS ADR1**. These surveys, each with its unique perspective, provide us with raw data, which we will meticulously process. With scientific precision, we will stack the perfect channels from this raw data to craft awe-inspiring images. Our masterpiece will include representations in **Optical RGB**, **IOU** (Input-Output Universe), and **ROR**

1 Introduction

This assignment delves into the exploration of distinct galaxies, venturing beyond our world to unravel the mysteries of the cosmos. Leveraging the power of Python libraries such as Astropy and Astroquery, we embark on a celestial quest. Seven diverse surveys, including **DSS2 Red**, **DSS2 Blue**, **DSS2 IR**, **WISE 22**, **GALEX Near UV**, **NVSS**, and **TGSS ADR1**, serve as our guides in obtaining raw data from NASA's SkyView repository. Our mission is twofold: to craft captivating images and to decipher the physical nuances of these celestial wonders. With precision and creativity, we transform raw data into images in three distinct formats: **Optical RGB**, **IOU** (Input-Output Universe), and **ROR** (Revealing Outer Realms). Through this assignment, we voyage into the cosmic unknown, shedding light on the beauty and science that reside in galaxies beyond our reach.Join us in this celestial odyssey as we capture the essence of galaxies and unveil the cosmic phenomena that paint the canvas of our universe.

2 Methodology

For this assignment I am using the Google Colab Notebook for editing and writing the Python code.

Astroquery and Astropy:

- Our cosmic journey begins with **Astroquery** and **Astropy**, our trusty astronomical guides. These libraries facilitate the retrieval of celestial images from NASA's SkyView repository. SkyView, a function within Astroquery, acts as our celestial GPS, requiring coordinates of the galaxy and the survey of interest to provide us with essential URLs.

Image Retrieval:

- Armed with URLs from SkyView, we employ the versatile **requests** library. This tool enables us to traverse the cosmic web and acquire the images corresponding to specific coordinates and surveys. The images retrieved are initially in the Flexible Image Transport System (FITS) format, a celestial language of sorts.

Image Transformation:

- The celestial language of FITS requires translation for human understanding. This translation is accomplished through the synergy of **Astropy** and **requests**. We convert the acquired FITS images into user-friendly formats such as JPEG, JPG, or PNG. Yet, these images often arrive scaled inappropriately, either too minuscule or gargantuan in scale.

Image Re-scaling:
- To bridge the gap between celestial enormity and human perception, we employ image rescaling. Through careful adjustments, we transform the images into observable dimensions, ensuring that the cosmic details are comprehensible to our human eyes.

Survey Diversity:
With the methodology in place, we embark on a survey-rich adventure. We repeat the entire process for multiple surveys, capturing distinct perspectives of our cosmic subjects. Each survey offers unique insights into the galaxies we encounter.

Channel Stacking:
The final act in our cosmic symphony involves the assembly of Optical, IOU, and ROR images. We deftly assign the Red, Green, and Blue channels, as outlined in the problem statement, and stack them together. This orchestration results in the creation of captivating compositions that unveil the celestial wonders we've encountered.

3 Survey Documentation

DSS2 IR:
This survey is generated by scanning Schmidt near-IR plates of the sky at 1" resolution it is an Infrared regime with frequency of 353 THz with Bandpass of 327-422 THz this survey has a coverage all over the sky

DSS Red:
This is a optical regime survey and has the coverage all over the sky the frquency of this survey is 445 THz and has bandpass of 442-564 THz

DSS2 Blue:
This is a Optical regime survey with entire sky coverage this survey operates in the frequency of 637 THz and with bandpass of 517-967 THz

WISE 22:
This survey is NASA's Wide-field Infrared Survey Explorer mapped at 22 micrometer wavelength, this is a infrared regime survey with lower frequency of 14 THz and bandpass of 12-15 THz, WISE 22 survey has full sky survey with a bit lower resolution as compared to DSS2 IR, WISE 22 has a resolution of 12"

GALEX Near UV:
This survey operates on ultraviolet regime with wavelength between(1770-2730 A) the coverage of the survey is patchy with resolution of 5.3" this observatory has a tangential projection.

NVSS:
NVSS is a 1.4 GHz NRAO VLA Sky survey it has a coverage of -40 Declination with Orthographic projection this is one of the less resolved observatory survey with resolution of 45", this survey has a pixel scale of 15"/pixel.

TGSS ADR1:
This survey is the first full relase of the GMRT 150 MHz All-sky Radio Survey it has a bandpass of 14-156 GHz this has a coverage of 0.9 of all the sky with north declination of -53, with Resolution of 25" and pixelScale of 6.2"/pixel

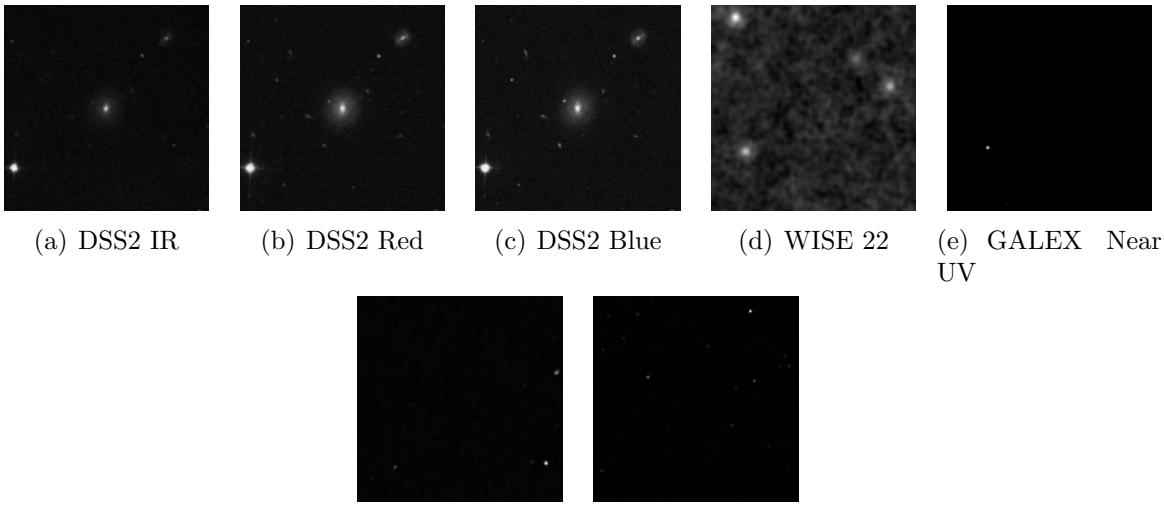
Stacking of these surveys: With all this surveys I had to create three images namely Optical RGB , IOU and ROR, these images can be obtained by stacking the specific colour channels of the surveys we obtained from th observatory

For obtaining the **Optical RGB** we have to stack three surveys namely DSS2 IR, DSS2 Red and DSS2 Blue for stacking we will take the Red channel of The DSS2 IR observatory , Blue channel of the DSS2 Blue observatory and the Green channel of the DSS2 red observatory and then we will stack all these different channel on top of each other to obtain the Optical RGB image.

For obtaining the **IOU image** we have to stack three surveys namely WISE 22, DSS2 Red and the GALEX near UV for stacking we will take the Red channel of The WISE 22 observatory , Blue channel of the GALEX Near UV observatory and the Green channel of the DSS2 red observatory and then we will stack all these different channel on top of each other to obtain the IOU image.

For obtaing the **ROR image** we will stack the red channel of the TGSS ADR1 blue channel of the NVSS and the green channel of the DSS2 Red. After we obrtain the images will try to predict the physical nature of the galaxies

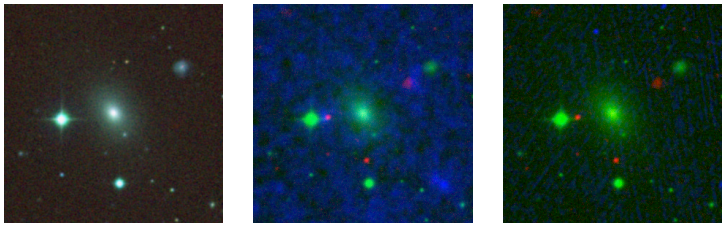
4 Image Samples



(a) DSS2 IR (b) DSS2 Red (c) DSS2 Blue (d) WISE 22 (e) GALEX Near UV

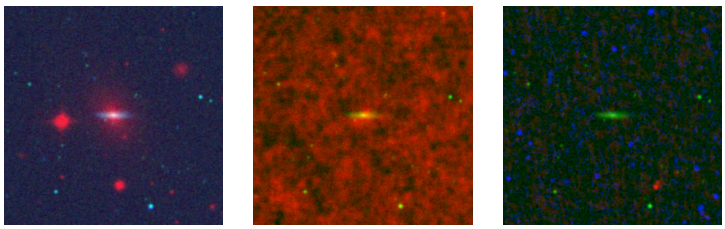
(f) TGSS ADR1 (g) NVSS

Figure 1: Sample out of all the surveys for J2000 coordinate system



(a) Optical RGB (b) IOU (c) ROR

Figure 2: Final Images after stacking



(a) Optical RGB (b) IOU (c) ROR

Figure 3: Final Images after stacking example 2

5 Technique used for Image Analysis

(a) Optical RGB (b) IOU (c) ROR

Figure 4: more sample images

5.1 Understanding the Colours of the images

We understand that the galaxies and the stars are the closest blackbody in the universe and hence the radiation emitted from galaxies are of the form of a black body radiation and hence we can get a rough estimation of the temperature of the galaxy surface or the star surface by studying the wavelengths that the galaxy emits and the strength of those wavelength.

For a blackbody we know that the dominant colours are the are of the wavelength corresponding to the peak wavelength of the blackbody radiation, hence with the knowledge of the dominant colour i an particular region we can have a rough estimation about the temperature of that region with the help of the Wien's displacement law $\lambda_{Max} = \frac{b}{T}$: Where **b** is the Boltzmann constant. With this knowledge I can say that for each RGB images created R G and the B color corresponds to different frequencies.

Now for this assignment I am encountering with 7 different surveys which has 7 different peak frequencies with the help of which i can comment on the temperature of the light source with the help of Wien's displacement law. The 7 surveys we are observing are DSS2 IR(353 THz), DSS2 Red(445 THz), DSS2 Blue(637 THz), WISE 22(14 THz), GALEX Near UV(851 THz), NVSS(1.4 GHz), TGSS ADR1(150 MHz).

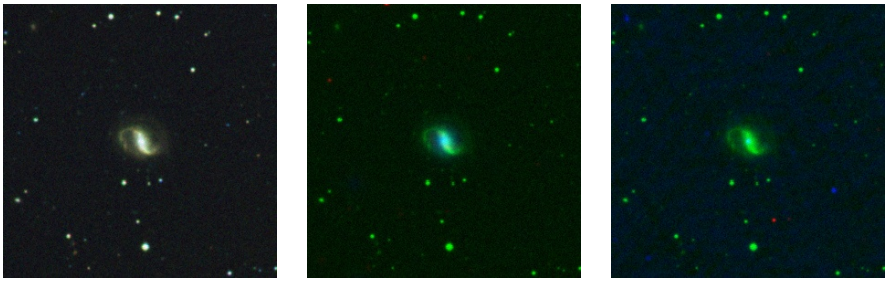
The temperatures of the source emitting this frequency will be $6005K^0$, $7569K^0$, $10{,}835K^0$, $238.14K^0$, $14{,}475K^0$, $0.023814K^0$, $0.0025515K^0$. After few studies and reading few chapters of Introduction to Modern Astrophysics by Bardley W. Carroll and DaleA. Ostlie understood that for the Star formation the average temperature of the nebula should be around 10k i.e 587.9GHz frequency of the radiation of the source and since I am not using any survey around that frequency it is difficult with the Survey details I have to comment on the star formation in a particular galaxy for analysing the star formation me might have to analyse if the galaxy is emitting radiation of something around 500GHZ-600GHz.

The red giants of the Galaxies have their surface temperature of around $4500K^0$ to $5000K^0$ i.e they will be emitting radiations in the range of Infrared region on the Electromagnetic spectrum hence we can detect Old stars in the universe with the help of the DSS2 IR survey.

Now the hot new stars in the galaxies have their surface temperature of around $10000K^0$ to as high as $50000K^0$ hence we can confidently say that the newborn stars emit UV radiation from the galaxy. Similar to this the galaxies emitting radio waves can be analysed with the help of the survey associated with the radio frequency NVSS and TGSS ADR1 wich on giving certain color channel will help us to analyse the radio nature of the galaxy.

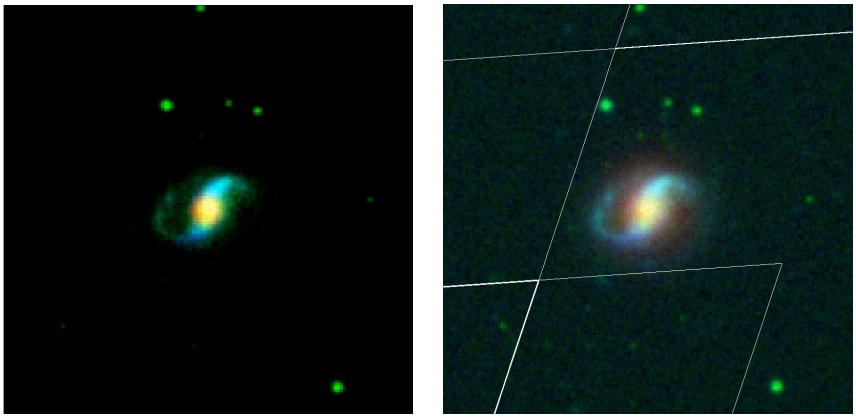
6 Observations

6.1 Galaxy coordinate ra: 330.8167 :: dec : 0.571094



(a) Optical RGB Image (b) IOU Image (c) ROR Image

Figure 5: Images obtained from stacking for analysing the physical aspect of data



(a) Enhanced IOU image (b) contour of 545GHz Radiation flux

Figure 6: Caption

As explained in the previous section we will do the image analysis for few galaxies firstly we will do the analysis for the galaxy at coordinate ra: 330.8167 :: dec : 0.571094, since our main intention is to comment on the star formation and related physical aspects for that our main focus will be in observing high energy radiation which indicates the presence of young hot star.

The main focus of my analysis will be using the IOU image obtain refer figure 5(b) and the enhanced image refer figure 6(a).

IOU image is obtained by stacking three images of different surveys and allotting those surveys particular color Chanel (Red channel for the WISE 22 survey, Green channel for DSS2 Red and Blue channel for the GALEX Near UV)

from figure 6(a) you can see that the center of the galaxy is yellowish color which indicates that the center is emitting both Red and Green color, here the red color means the presence of infrared radiations which indicates the presence of red giants (Old stars). The arms are having blue color which corresponds to UV regime which indicates the presence of young hot stars, referring to the figure 6(b) I can say that within the Galaxy there are no active nebula's which can led to the star formation.

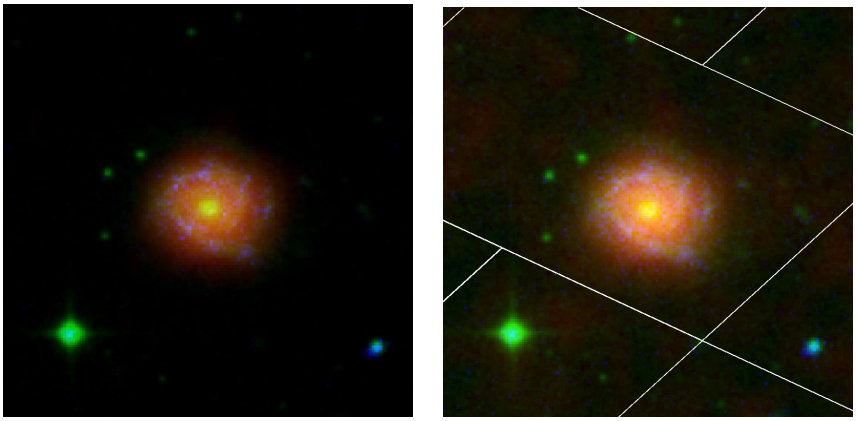
conclusion

This is a bard Spiral Galaxy which has old stars at the center of the galaxy and new hot stars at the arms and there are very very less possibility of star formation. These are no radio galaxy as in figure 5(c) we optical DSS2 Red Dominance which I have assigned with Green Channel.

6.2 Galaxy coordinate ra: 240.669 :: dec: 37.35949

(a) Optical RGB Image (b) IOU image (c) ROR Image

Figure 7: Images obtained by Stacking for analysing the physical aspect of the data



(a) Enhanced IOU Image (b) Contour of 545 GHz radiation flux

Figure 8: Enhanced image for In dept analysis

As explained in the previous section we will do the image analysis for few galaxies firstly we will do the analysis for the galaxy at coordinate ra: 240.669 :: dec: 37.35949, since our main intention is to comment on the star formation and related physical aspects for that our main focus will be in observing high energy radiation which indicates the presence of young hot star.

The main focus of my analysis will be using the IOU image obtain refer figure 7(b) and the enhanced image refer figure 8(a).

IOU image is obtained by stacking three images of different surveys and allotting those surveys particular color Chanel (Red channel for the WISE 22 survey, Green channel for DSS2 Red and Blue channel for the GALEX Near UV)

from figure 6(a) you can see that the center of the galaxy is yellowish color which indicates that the center is emitting both Red and Green color, here the red color means the presence of infrared radiations which indicates the presence of red giants (Old stars). The spiral arms are having blue color which corresponds to UV regime which indicates the presence of young hot stars, referring to the figure 8(b) I can say that within the Galaxy there are no active nebula's.

conclusion

This is a Spiral Galaxy which has old stars at the center of the galaxy and new hot stars at the arms and there are no sign of star formation in this galaxy, their is also no sign of radio frequency emission from this galaxy as you can see from figure 7(c) that the image is dominated by the green color which corresponds to the visible range, hence this is non radio galaxy.

7 Conclusion

I have successfully obtained and stored images of different catalogs using python programming language in the Google Colab Notebook with the help of Astroquery and Astropy these are inbuilt libraries in python for very mentioned survey and then stacked them to for the Optical, IOU and ROR images.
The Enhanced images figure 8 and figure 6 were obtained with the help of ds9 software to reduce the background noise and plot the contour which help us to do some deep analysis.

8 Future scope

I tried to plot the contour of the TGSS and NVSS for that I downloaded the data of the NVSS and TGSS flux for different coordinates, while plotting the contour i encountered a hardware error for low space for storing the contour data in python, i am still working on reducing the flux data for coordinates closer to the galaxy catalog so that I can plot the contour within the galaxy. The code is explained in the ipython notebook share. I am also working on the Intensity mapping of different channel so that I can extract maximum information from the obtained image, more surveys can be used according to the requirement and cause of analysis.