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Stratis Alloimonos

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Space photo processing

Stratis Alloimonos
3rd High School of Alexandroupolis ''Domna Visvizi'', Alexandroupolis, Greece
stralloimonos@gmail.com

Supervising professor: Tsakiris Dimitris
ΠΕ04.01, Physics professor, 3rd High School of Alexandroupolis ''Domna Visvizi'', Alexandroupolis, Greece
dtsakiris65@gmail.com

Abstract:

During the last academic year, our school's **Astronomy Group** focused its research on the exploration and study of space, its **stellar objects** and **phenomena** that take place out there. As part of the so-called **D-SPACE** project, in collaboration with few other educational institutions of our country, we decided, in cooperation with the **Skinakas Observatory** and the **University of Crete**, to request to acquire pictures of certain stellar objects, visible during the summer period.

The editing of space photographs is considered to be one of the most controversial issues, with many conspiracy theorists calling it an act of propaganda by the major space companies to present a fake image of space rather than the real one. Particularly, this issue came to a climax over the past year following the release of the photos by NASA's **James Webb Space Telescope (JWST) and the reactions that ensued over the "vividness" of their colors**. Following my personal extensive research and, in accordance with the opinion of the majority of the scientific community, I attempt through this research to logically refute the aforementioned argument and **highlight the benefits of processing space images**, taking also into consideration my own personal experience of processing the Skinakas images.

Keywords:
processing; data analysis; details; mix; RGB; characteristics

SECTION 1

Introduction:

*Major space companies such as **Nasa** employ a large number of expert technicians who are solely responsible for the **meticulous** and **accurate** processing of astral telescope images and their conversion into imagery that can actually **be perceived by the human brain**. (Admin, 2023)*

Why are telescope images processed?

1. Telescope images are captured in the **grayscale** (monochromatic). (Ward-Bailey, 2015). This is because these sensors only record **photons**; not their color. In addition, such black and white sensors **utilize the full possible light in the environment**, unlike ''color'' sensors, which repeat the process for each filter (**red, green, blue**). Therefore, the black and white image is much sharper than the color image.

However, it should be noted that the human eye **has difficulty in distinguishing** all shades of grey. Consequently, it becomes difficult to grasp all the visual details of the stellar object based on the single-color photograph. (Cheddar, 2019, YouTube).

2. The sensors that take pictures in space do not usually utilise light visible to us, but **UV (ultraviolet radiation)** or **infrared light** that must be carefully converted-translated into the spectrum we can actually see (Frąckiewiczin, 2023).

3. When we study complex shots (i.e. galaxies) some elements of the object emit waves outside the visible spectrum, **so they are not perceived by the human eye**. Through processing and using appropriate detectors, technicians can highlight and add bright colors to these spots to render them visible (Sutter, 2016).

4. Each hue of color in a stellar image carries an important role as it **indicates specific chemical elements** that comprise the basic composition of both the universe and its phenomena. Different elements also emit varying **lengths of light**, thus acquiring a different colour that distinguishes them from others (Cheddar,2019, YouTube):

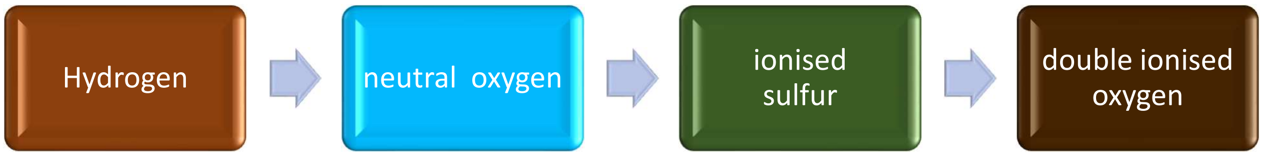
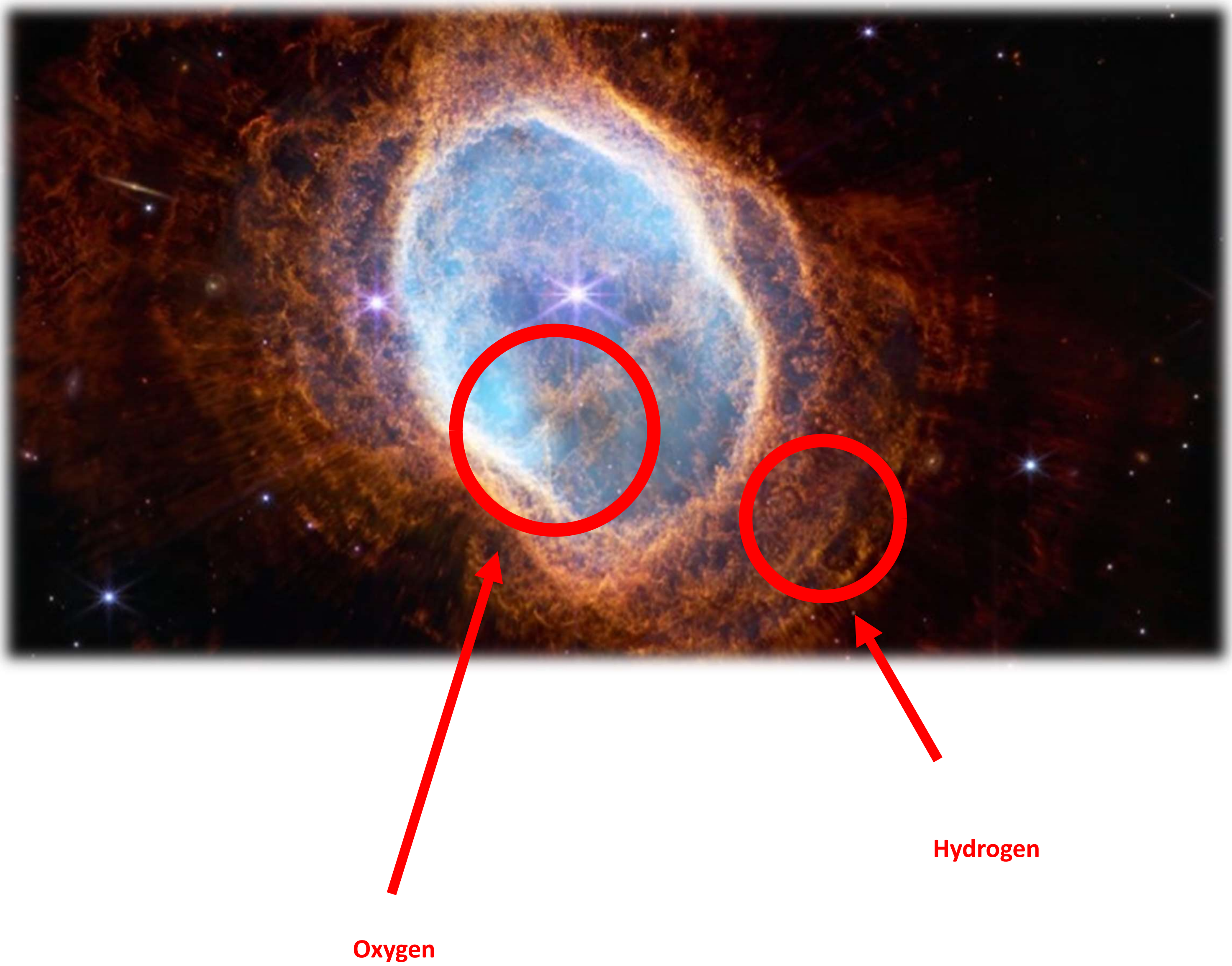


Figure 1: The correspondences between the colors of a star image and the chemical elements they represent

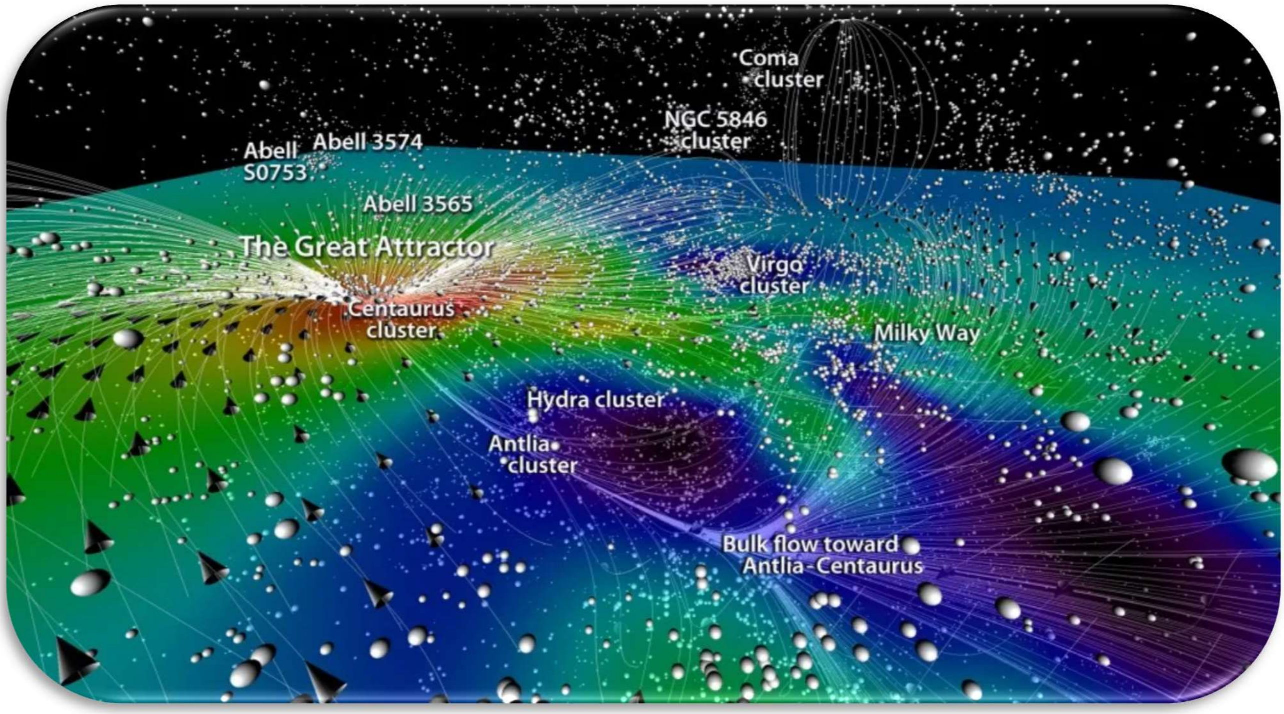


Example 1: Each color represents one chemical element

"**I basically take raw grayscale data from different parts of the infrared spectrum, and then remap them into visible colors, to create images that are accurately representative of the infrared colors that human eyes cannot see**" CalTech's Robert Hurt highlights and points out:

"I think of it as a visual translation process." (Hurt, 2015)

Through the digital processing of the images, a map depicting the universe is simultaneously developing. The human eye is characterised by lots of weaknesses that can be overcome by digital editing. (Sutter, 2016)



Example 2: Mapping the universe in relation to its chemical elements

Furthermore, it essential to be mentioned that there **are two types of space photo editing**:

- The one done with the use of amateur digital programs, aiming at **the aesthetic improvement of the image**, but not necessarily the scientific depiction and its accuracy- flawlessly.

- The processing with a view to the **best possible illustration of the astral objects for the facilitation of the scientific study and the comprehension of the observed object**.

Generally, it is the second method which predominates. As **Paul Sutter**, an astrophysicist in the University of Ohio has emphasised: ''The image's processing is **90% for the benefit of science and 10% for the benefit of the public''.** (Shutter, 2019)

Note

Major Space Companies make available the raw data to the public, so that the scientists around the world take advantage of the opportunity to conduct their own research into the accuracy of the observations. In this way, a collaborative environment is enhanced and the will for more scientific research is fostered. (Admin, 2023)

SECTION 2

Skinakas image processing

1. Telescope shots

Based on the **Celestron Messier Catalogue**, as a team, we initially selected the objects based on visual attractiveness. We also made sure that these objects were situated **high on the horizon** during the summer season and that **the Moon** was located relatively far away to avoid being affected by its shadow and light, so that we could secure optimal conditions for the best and sharpest images. We thus chose the following:

- ✓ A Globular Star Cluster **(NGC 6934)**
- ✓ Two Spiral Galaxies **(NGC 7331 and NGC6946)**

- ✓ The remnants of the explosion of a supernova (**SNR**)
  (what we call **nebula – NGC 6992)**

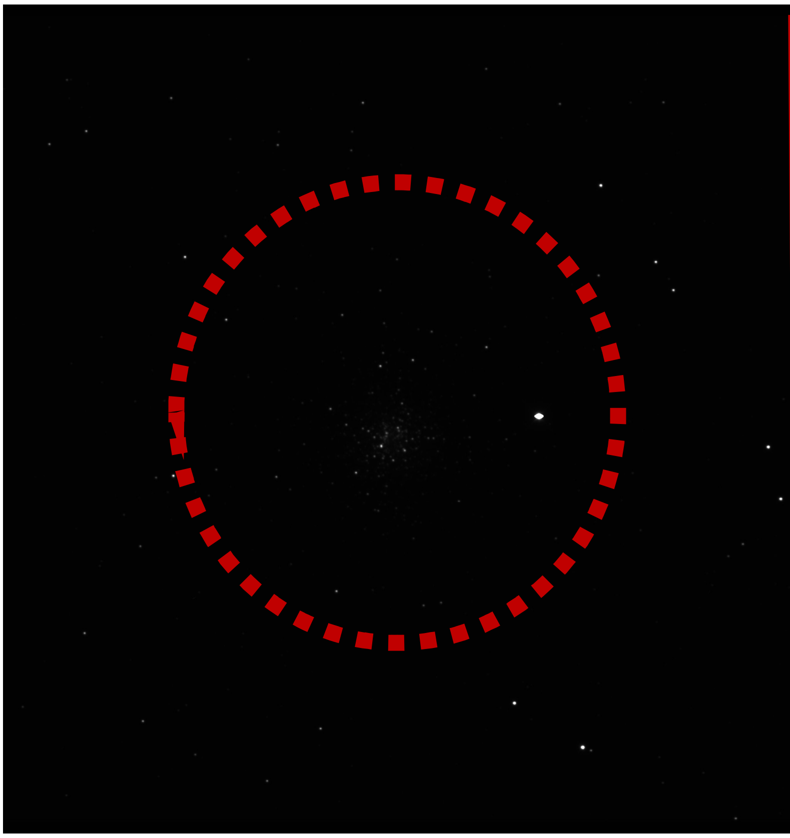
2. Skinakas Telescope Capabilities

It is worth knowing the telescope's technical characteristics in order to compare the same object image taken by different telescopes. It has what is known as a **Focal Reducer**, which more than doubles the field of view of the telescope, which is particularly important for photographing objects that **cover a wide field**. In addition, it is equipped with an **Autoguider** system and finally it features a set of optical filters (Risse, 2006), (Wikipedia, 2023). The camera used is **near-infrared**; that is, it uses the radiation emitted by a wide range of sources, mainly cold stars (which are usually those with small masses). Low-mass stars are the most prevalent in space, which is very convenient for near-infrared star photography. The telescope is located at a high altitude (**Mount Ida, Psiloritis**) in order to avoid the high levels of city light pollution, which greatly affect our exposures. (Retrieved from the official website of the Skinakas Observatory)

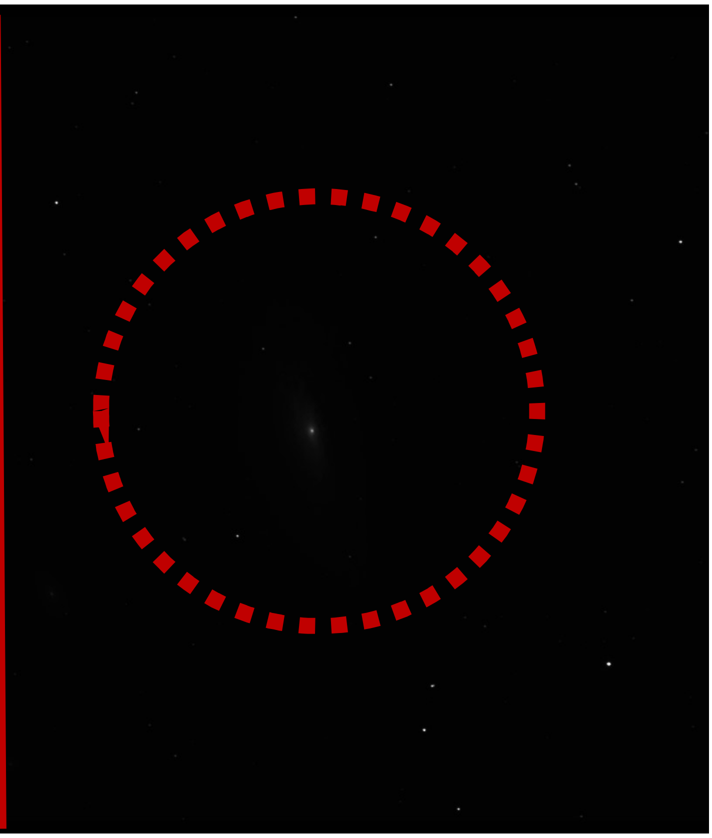
(Retrieved from the official webpage of the Skinakas Observatory)

Picture 1: The Observatory at Skinakas

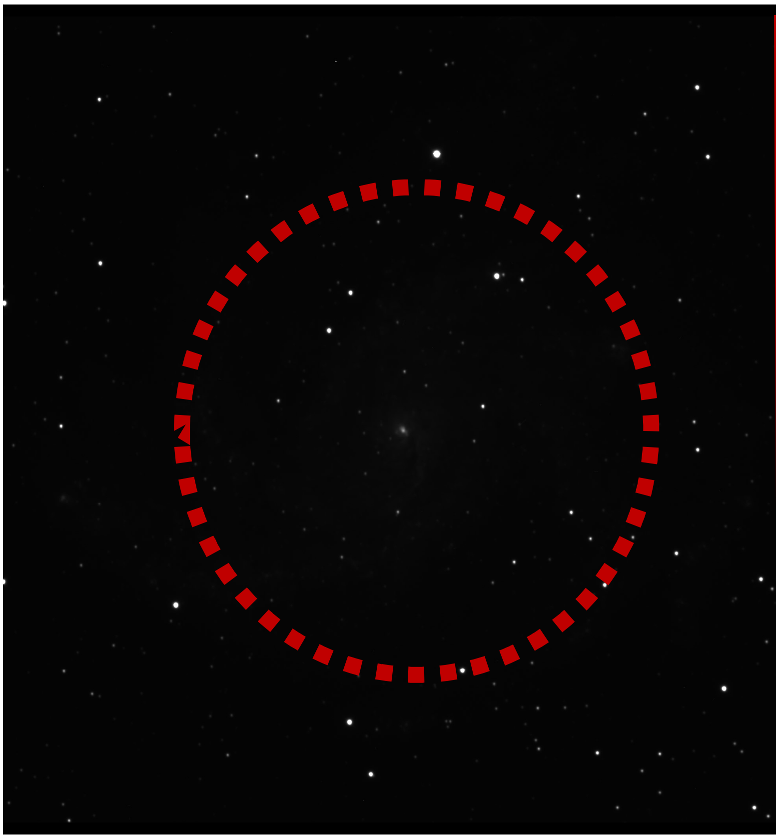
The images sent directly from Skinakas, without technical processing, (**as mentioned in the previous section**) were black and white and therefore difficult to analyse. In fact, each object is not clear individually, **as it is faint in the shot**.



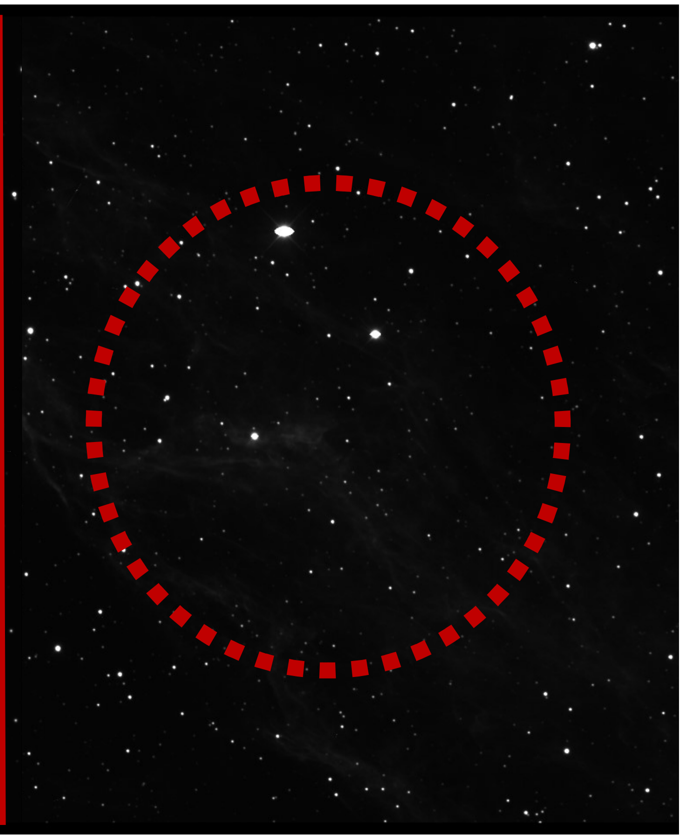
Picture 2: The shot of the Globular Cluster taken by the telescope **(NGC 6934)**



Picture 3: The shot of the first spiral galaxy taken by the telescope **(NGC 7331)**



Picture 4: The shot of the second spiral galaxy taken by the telescope **(NGC 6946)**



Picture 5: The shot of the supernova star's remnants taken by the telescope **(NGC 6992)**

Since the features that provide information about each object are unclear (which is not convenient for data analysis), **I commenced** the procedure of processing each shot in each filter (red, green, blue) and their final merge in **RGB**.

3. RGB color model

As is well known, color as we perceive it does not exist. In other words, **there is no property of the object called color**.

What we scientifically call "color" **is a limited part of the spectrum of electromagnetic radiation**.

color	Wavelength interval	Frequency interval
Red	~ 700–635 nm	~ 430–480 THz
Orange	~ 635–590 nm	~ 480–510 THz
Yellow	~ 590–560 nm	~ 510–540 THz
Green	~ 560–520 nm	~ 540–580 THz
Cyan	~ 520–490 nm	~ 580–610 THz
Blue	~ 490–450 nm	~ 610–670 THz
Violet	~ 450–400 nm	~ 670–750 THz

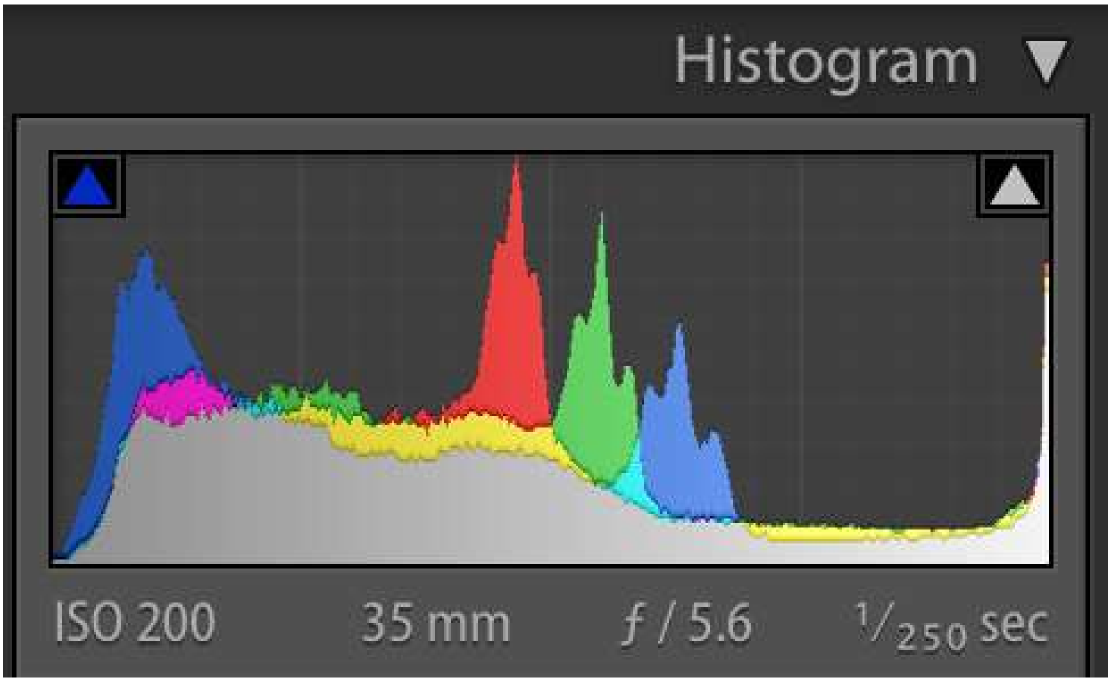
Table 1: The visible light spectrum

Light is actually a range of frequencies. When light strikes an object, the object absorbs some of the frequencies, and reflects the rest. **For instance, a yellow object is one that absorbs all but those in the yellow spectrum**. (Trantzas, 2016)

So, when these frequencies are received by the human eye, specific brain cells are affected and interpret each frequency as a unique colour. It therefore follows that **colour is subjective and each human brain perceives it differently**.

Thus, there arose the need for standardisation of colors, so that each colour **corresponds to a mathematical value**. In this way, the final form of the image results in a set of **pixels**, each consisting of different combination of colors. (Trantzas, 2016)

The technique used in modern photography **is to take three different shots of the same image with different filters**. **Each filter allows only light of specific wavelengths to pass through, which match a particular color**. In the end we get three pictures (all in the grayscale, but each containing information about a specific wavelength). Afterwards, they are automatically combined together and we get the color version of the image. (Jäger, 2021)



Example 3: Colors in video capture

In a similar way, the telescope observes each stellar object for:

5 minutes using the first filter (**red**), **5** minutes using the second one (**green**) and 5 minutes using the third one (**blue**).

We should note that photos are greyscale again (see section one); **however, for example, using the blue filter, the photo will only contain information about the blue photons**. (Jäger, 2021)

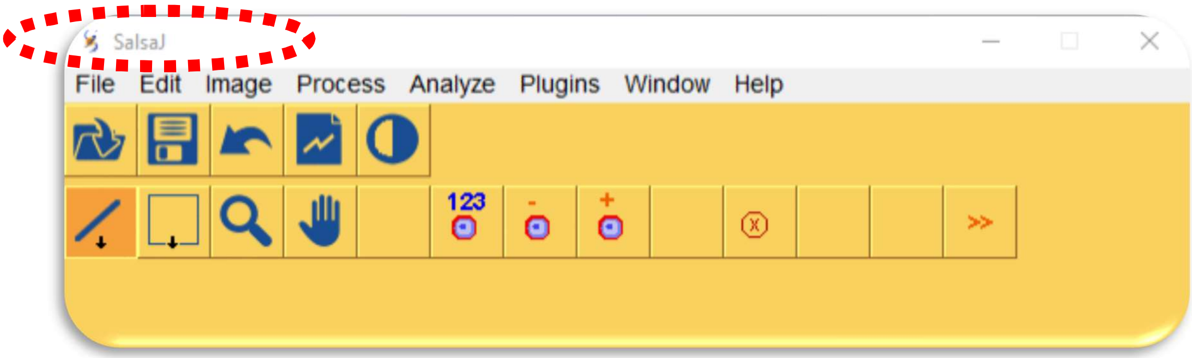
We technically have the capability to assign colors to the object manually and subsequently mix the three, different shots in one, called the **RGB** version. At the end of the procedure, we get the **detailed, colored version of the observed object**. (Smith, 2015)

Example 4: The wheel of a telescope's filters

4. Methodology used for the Skinakas photo processing

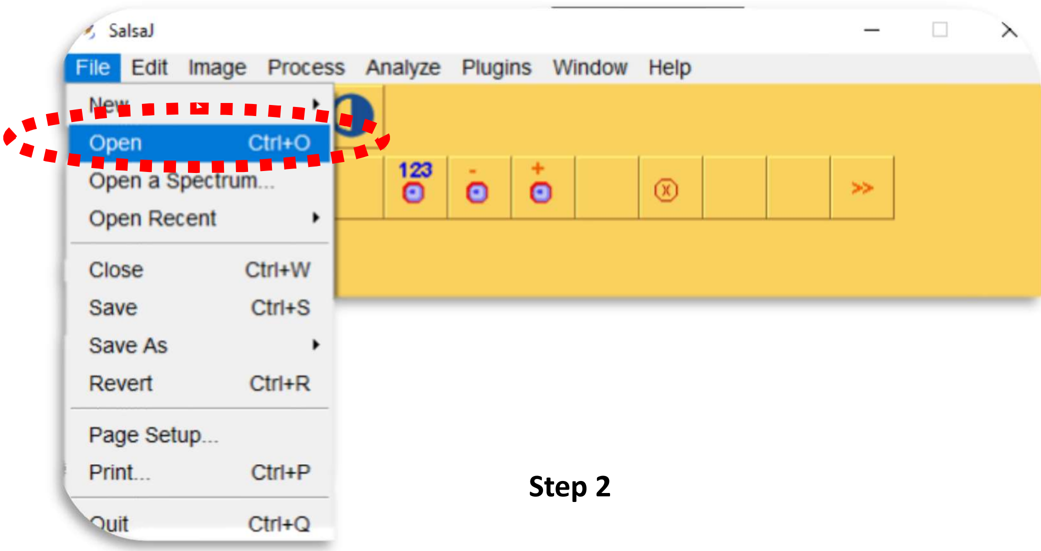
The program I utilised for the photo editing was ''**SalsaJ**''; it is a rather simple digital program, ideal mainly for students, which simultaneously indicates the procedure that the professional astronomers follow to edit astral photos. So, the steps I took were straightforward as follows:

i. Firstly, I ran ''**SalsaJ**''



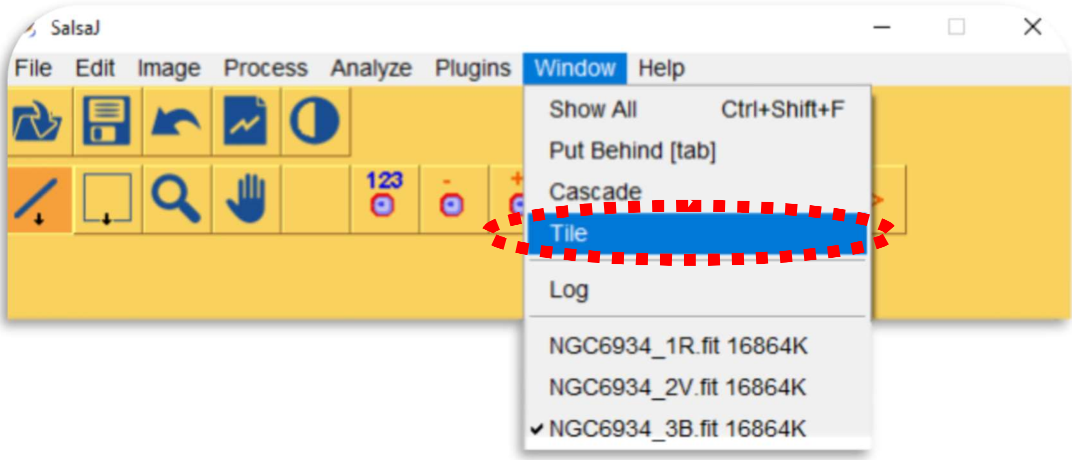
Step 1

ii. Then, I selected **File >Open**, to gain access to the telescope imagery.



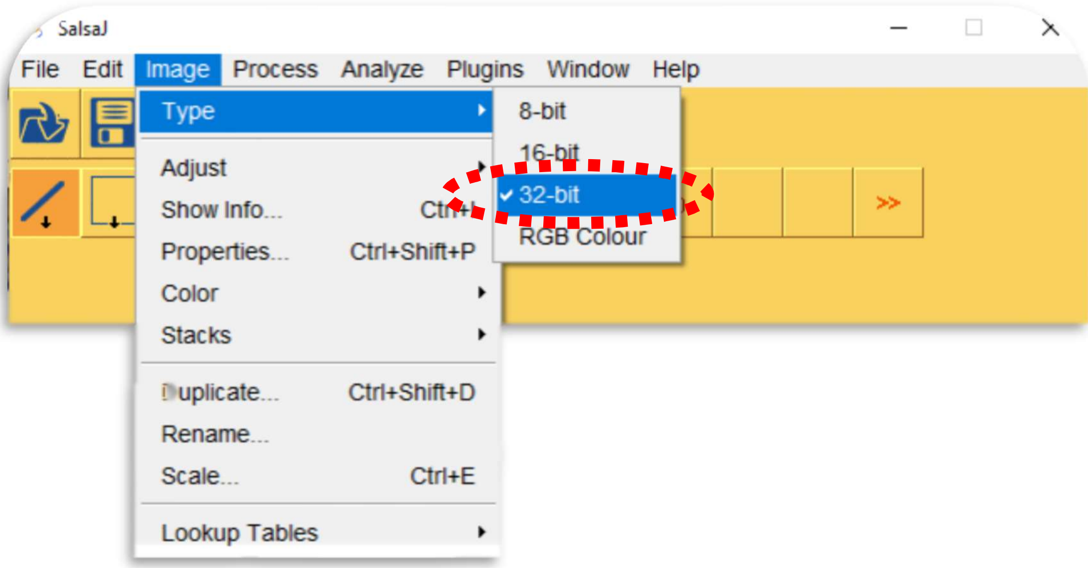
Step 2

iii. I placed each picture next to other by selecting **Window>Tile**.



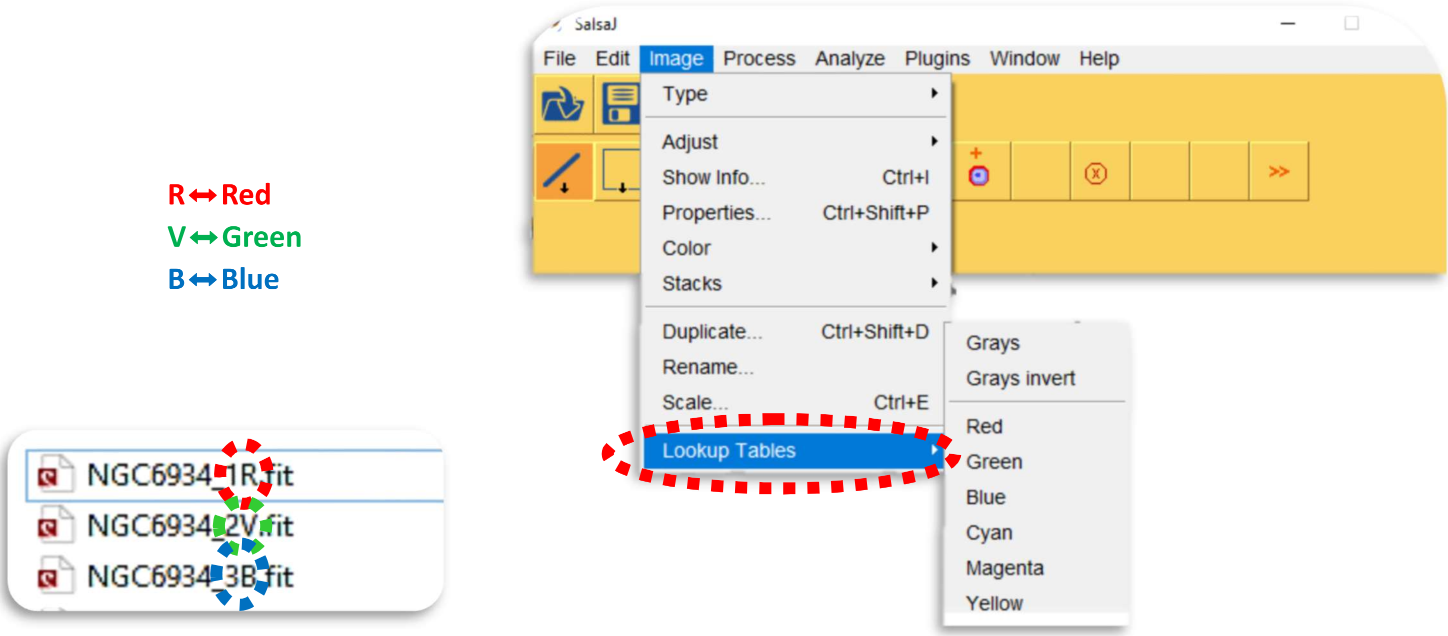
Step 3

iv. Afterwards, I selected **Image>Type>32-bit** in order for the pictures to be rendered in the best possible way in terms of color.



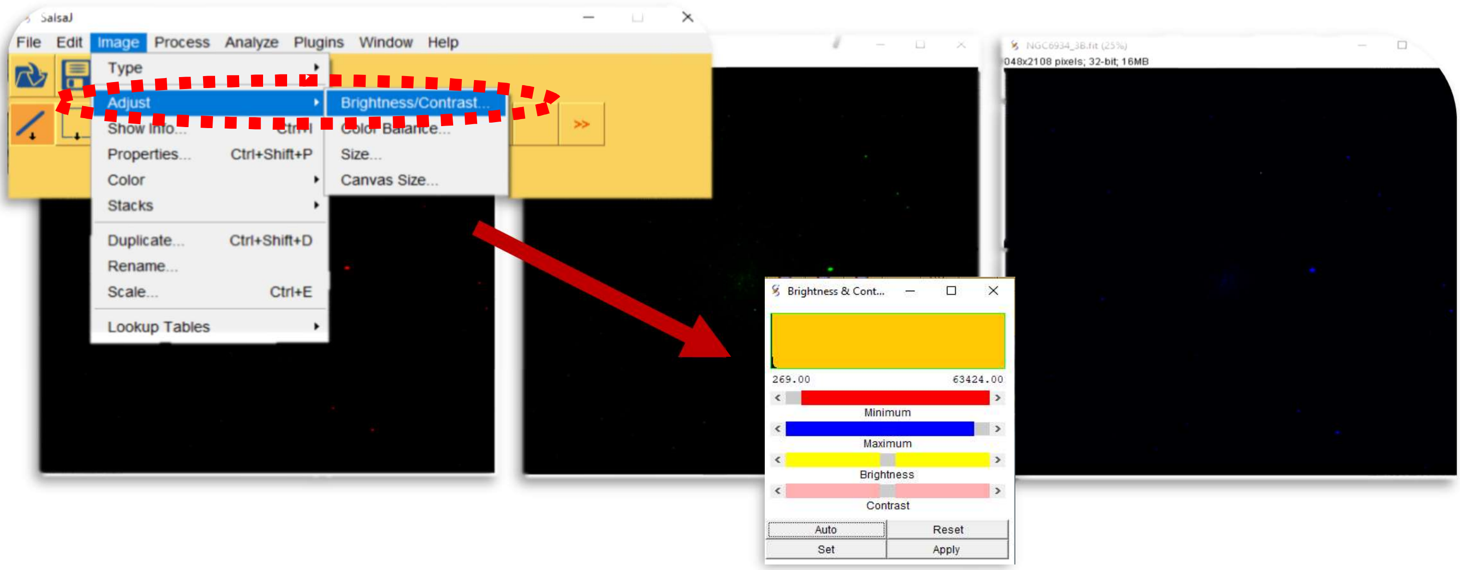
Step 4

v. After that**,** I matched each photo to its color selecting to **Image > Lookup Tables**.



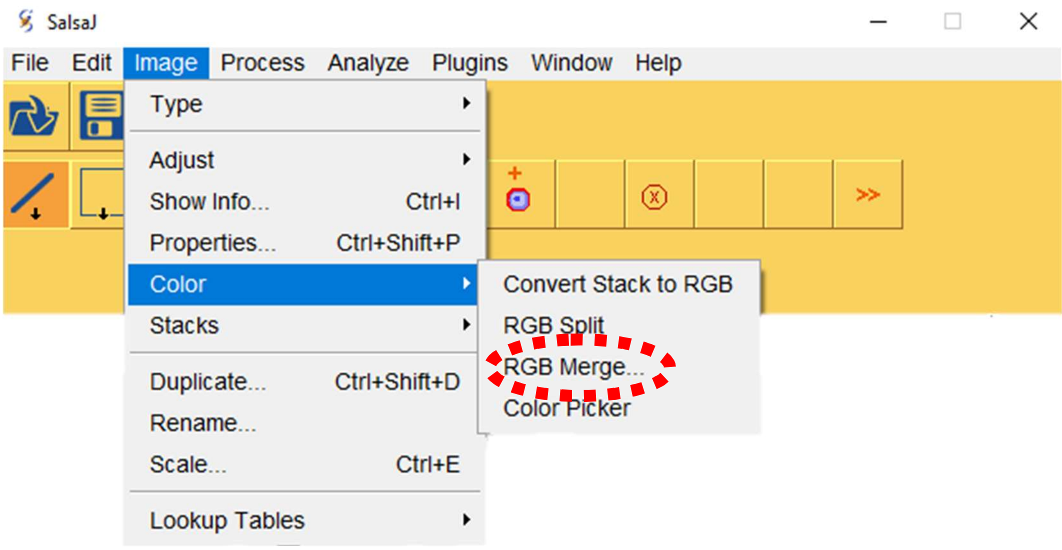
Step 5

vi. Then, I adjusted brightness and contrast for each image selecting **Image>Adjust>Brightness/Contrast** up until each and every detail in every colored section could be distinguished, based on shots of the same object, taken by other telescopes, so as to achieve the most detailed result.

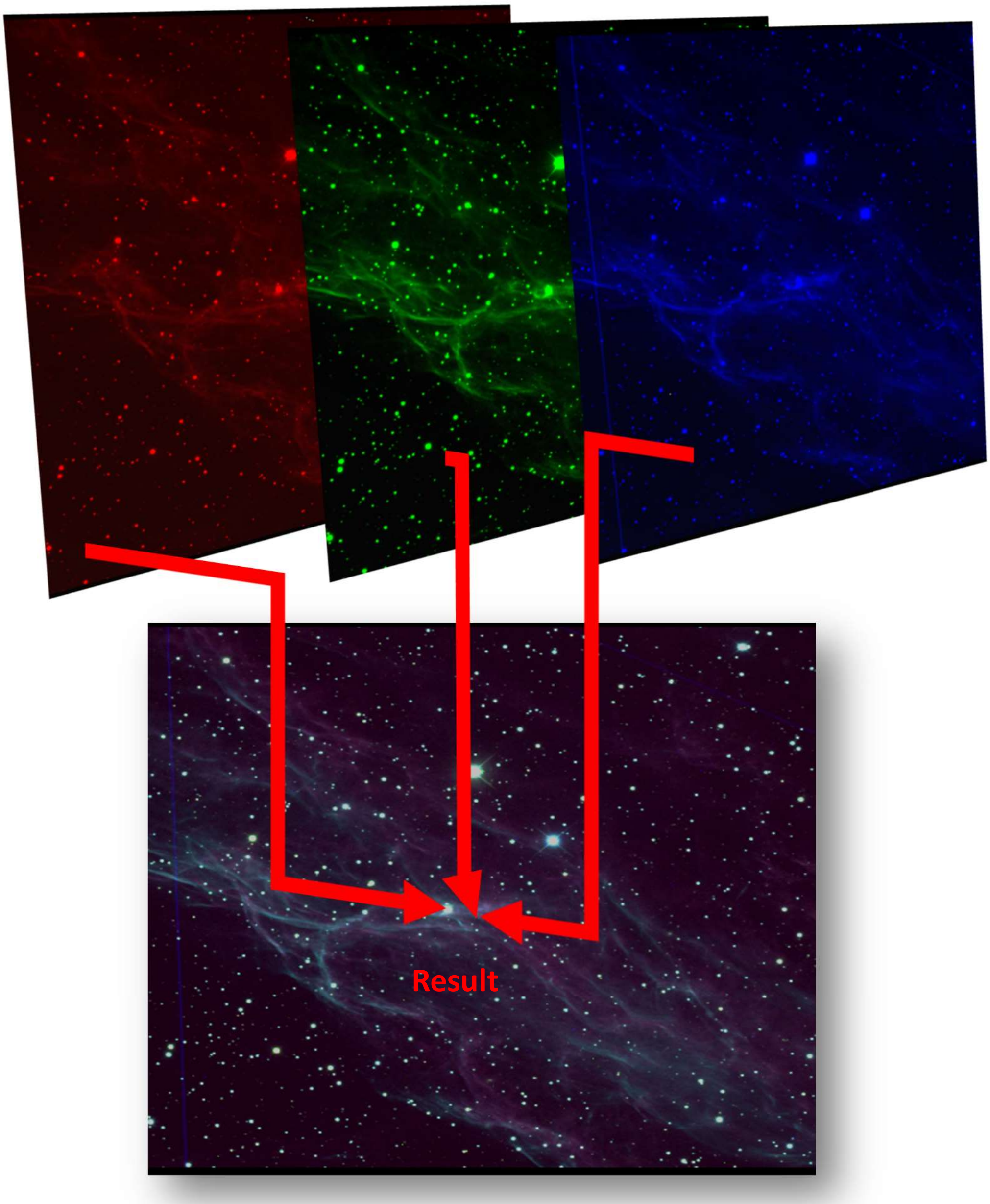


Step 6

vii. Finally in order for me to create the final colored picture, I selected **Image>Color> RGB Merge,** matching each photo to its corresponding colored filter.



Step 7



Example 5: The mix of the remnants of a supernova star's shots (using the three filters) in RGB

SECTION 4

1. Results

Picture 6: The result of the Globular Cluster shot (**NGC 6934)**

Note

NGC 6934 is situated in the constellation of Delphinus and is **52 kilolight-years from the Sun**. It exhibits a wide range of photometric anomalies. (Wikipedia, 2023)

Picture 7: The result of the first spiral galaxy shot (**NGC 7331)**

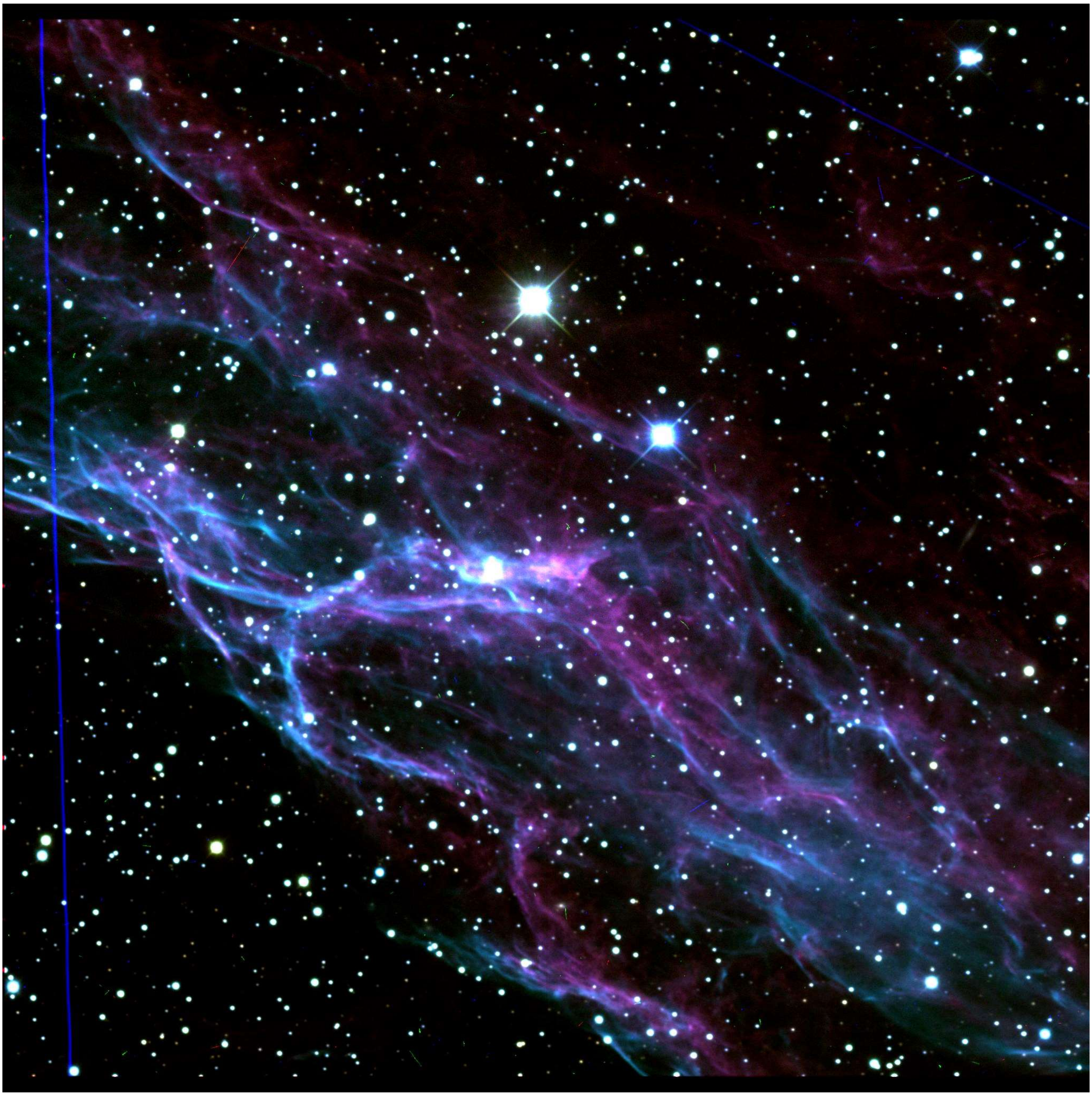
Note

NGC 7331 is about **45 million light-year** from Earth and it is placed in the constellation of **Pegasus**. It appears to have a plethora of similarities with the Milky Way in terms of structure and size. In fact, there is a tendency to call it ‘’**the Milky Way’s twin**’’. It is one of the brightest galaxies and emits **X-rays** and **radio waves**. (Wikipedia, 2023)

Picture 8: The result of the second spiral
galaxy shot **(NGC 6946)**

Note

NGC 6946 is located between the constellations of Cepheus and Cygnus, approximately 25 million light-years from Earth. **Due to its distinctive shape and because in it have been observed ten supernovae, it is also called Fireworks Galaxy.** (Wikipedia, 2023)



Picture 9: The result of the supernova remnants shot
(NGC 6992)

Note

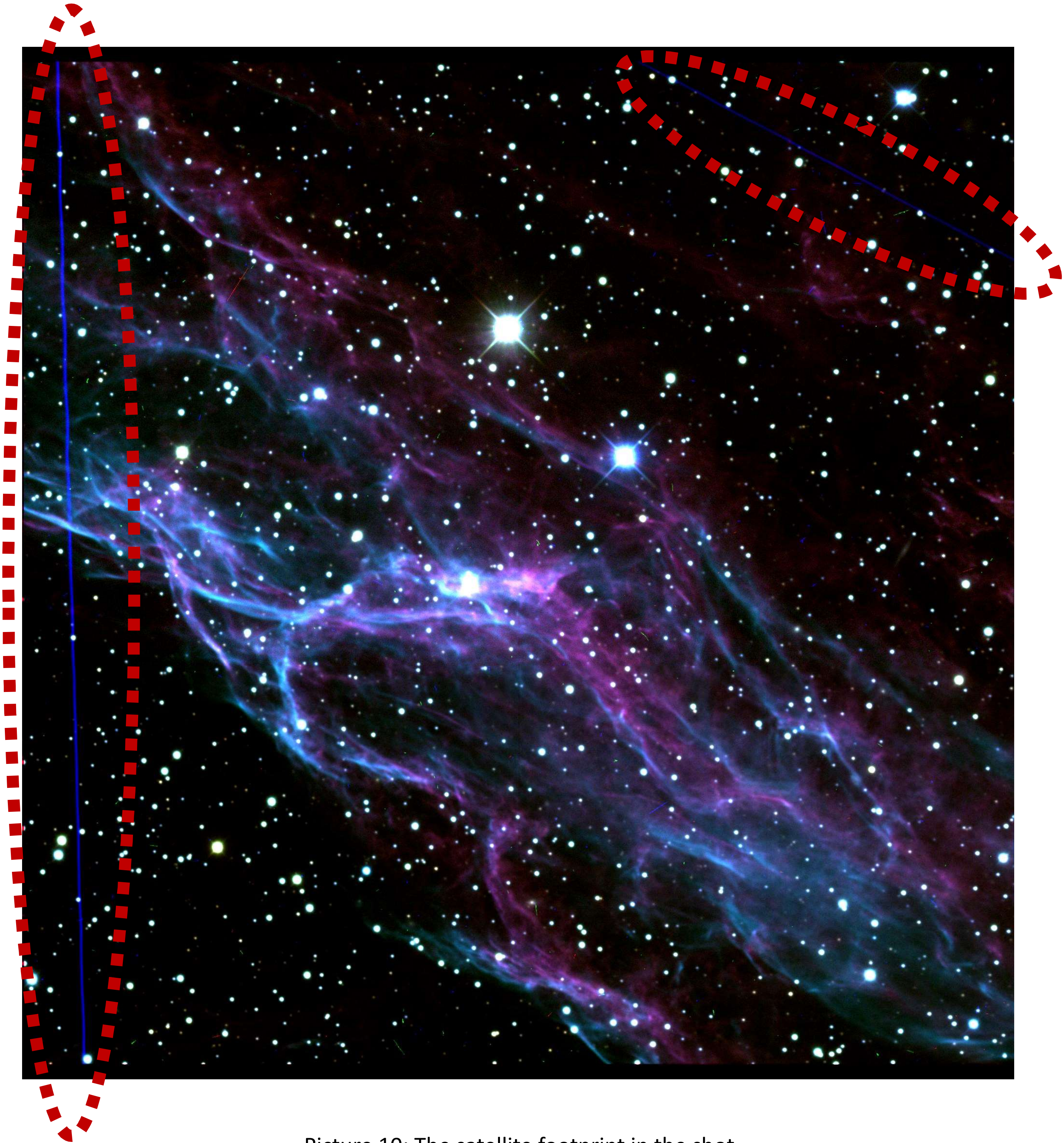
The shot does not depict the entire nebula owing to the fact that telescopes are not capable of observing such a wide field. The supernova source is estimated to have been a star **20 times more massive than the Sun, which emitted energy and light so powerful that it surpassed Venus in bright and it was visible even during the daytime on Earth.** Probably, it exploded from 10.0000 to 20.000 years ago. (Wikipedia, 2023)

2. Evaluation

To conclude, we would say that the difference between the initial captures and the results is considerable on the grounds that essentially the photo became **plus beautiful aesthetically**, while at the same time the color display we are able to **derive a variety of information** such as :

Example 6: The information that we receive about the chemical elements that make up each astral object

Furthermore, special reference should be made to this **strange, blue ''line'', which can be noticed in the photo** with the remnants of a supernova.



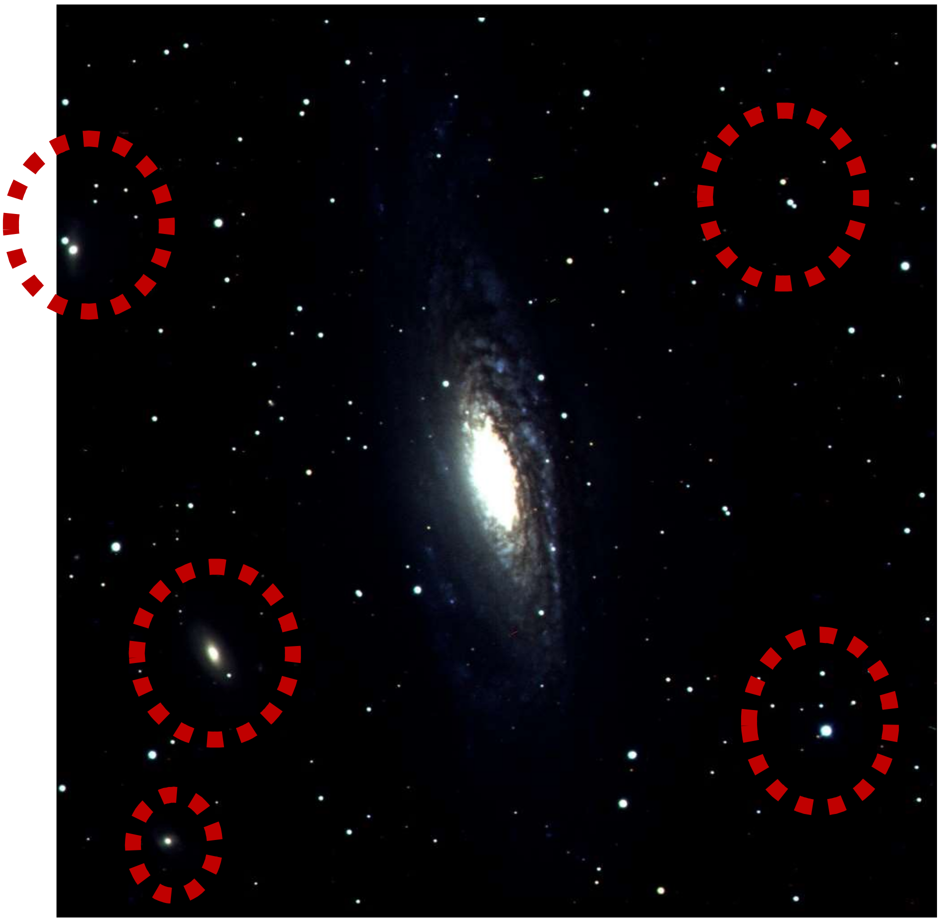
Picture 10: The satellite footprint in the shot of the supernova remnants **(NGC 6992)**

While the telescope was observing the object **using the blue filter**, a satellite was near the supernova remnants and its route is recorded **as the bold, blue line in the picture above**.

Even taking into consideration the above example, we notice that everything in an astral photo is meaningful. **Nothing is fake and pointless to exist**.

Plus, not only does a space image reveal data for one astral object, but the telescope is also, not so well every time, capable of providing information about other galaxies or stars depicted in the picture.

Particularly, in telescopes of a high accuracy (e.g James Webb and Hubble), this can be done in great detail, indeed (Ward-Bailey, 2015).



Example 7: The other stellar object seen
in the galaxy **NGC 7331** shot

SECTION 4

A. Conclusion

Through this research project, the main thing that I have come to understand is that **art and informatics working together with science is of outmost importance and deemed a necessity**. For many years there has been a perception specifically targeting art, that it is not a field of science and that it is something subordinate. On the contrary, the main conclusion that emerges through this study is that the collaboration of art with all fields of science and information technology can have a positive effect on the facilitation of research. **After all, this is why Nasa recruits a large number of specialists in this field to carry out the editing.** Yet alongside art, the **beauty** and **immensity** of the universe is perfectly emphasized in a unique way.

Space photos may look similar to the spectacular ones on social media (in terms of **filters** and **colours**), but there is a fundamental difference. Astronomers use **real data**, in **real time**, and simply sharpen them so that they are clearly visible to the human eye but also entice people to engage and seek out more information about each object depicted.

In our journey to explore space, we can therefore entrust without hesitation the processed astral photographs to be **a true and enchanting journey to the beauty, perfection and complexity of the universe**, combining the **rigour** and **precision** of the science of **Astronomy**, which is far from being forgotten or lost by the general public.

B. Acknowledgments

In conclusion, I would like to warmly thank my physics professor **Mr. Tsakiris Dimitris**, **who honored me with his trust to carry out my first scientific research.** In addition, his excellent and diligent scientific guidance and assistance with the processing part of the stellar images were quite valuable for the development of the research. Finally, the opportunity that he offered me to enter into the depths of what I would call a **difficult** and yet **fascinating** issue was particularly important as, even if only for a short while, it prompted me to think like one, i.e. a young scientist and study various references in order to come to a **sound conclusion** and attempt to **restore the truth**.

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