Ages: 14 years old

SCIENTIFIC CASE:

Study of celestial bodies in several ranges of the electromagnetic spectrum

Team members

Writer: ______________________________________

Equipment manager: _____________________________

Reader: _______________________________________

Spokesperson: __________________________________

Ambassador: ____________________________________

Context

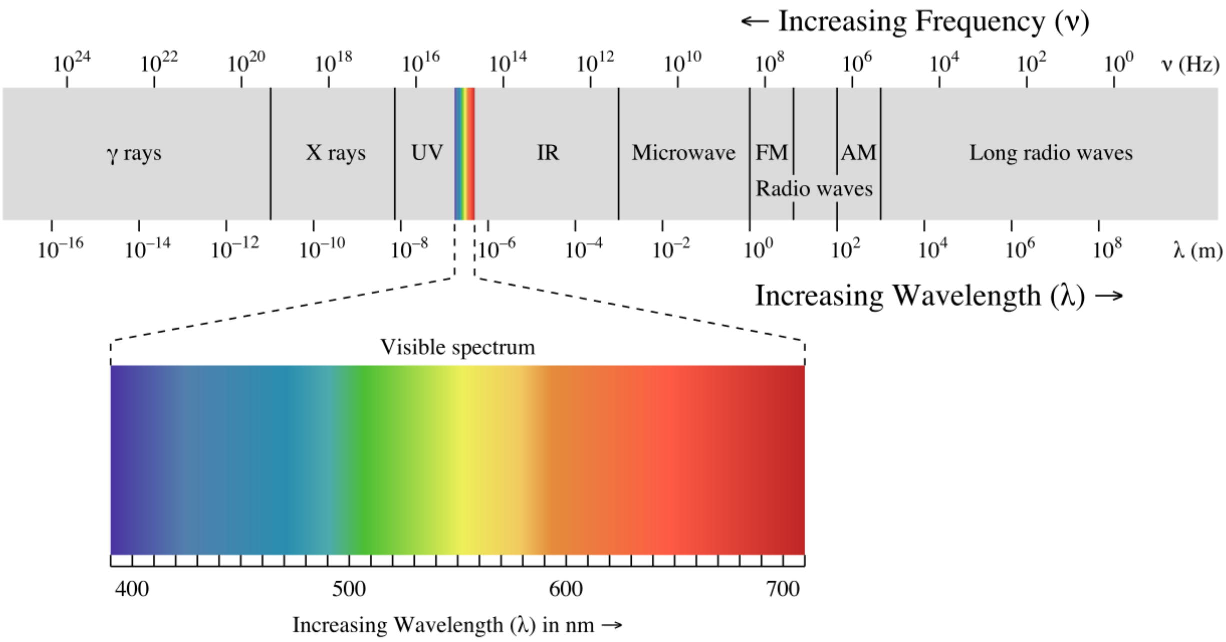
If we look at a rainbow, our eyes can see from red to violet.

Arcoiris. Credit: Wikipedia.org

However, there are other “colours” that our eyes can't see, beyond red and violet: **infrared and y ultraviolet**. In this picture of the rainbow taken in these three “types of light”, the rainbow appears to go far beyond the visible light.

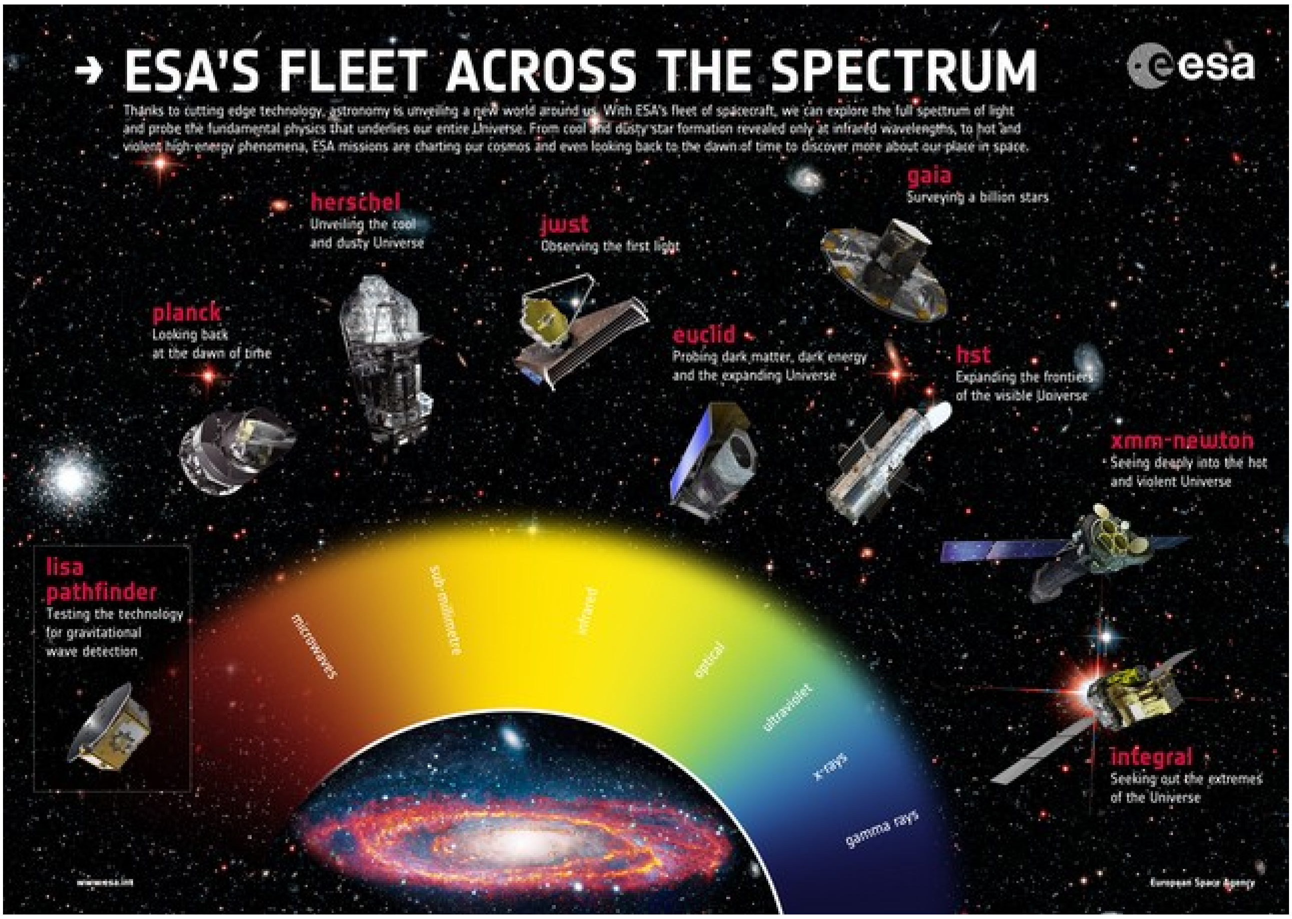
Multispectral rainbow. Courtesy of Dr. A. Dominic Fortes, Earth Sciences.

In addition to ultraviolet and infrared, there are other “colours” which are hidden from our our sight. We call the whole set of “colours” the **electromagnetic spectrum**, and we divide it in **ranges**, in order from the highest to the lowest energy: **gamma rays**, **X rays**, **ultraviolet**, **visible light**, **infrared**, **microwaves**, **radiowaves**.



Electromagnetic spectrum. Source: Wikipedia.org

Nowadays, the European Space Agency has a fleet of satellites which can observe the universe in all the ranges of the **electromagnetic spectrum**. To obtain a complete information of the different process that take place around the observed astronomical objects.



ESA's fleet across the spectrum. Credit: ESA

We are going to study the sky in these "**colours**".

More educational resources:

http://www.cosmos.esa.int/web/cesar
http://soho.nascom.nasa.gov/classroom/spectroscope.html

Scientific Case: Study of Earth and Moon using their different spectra

Research equipment

You have access to the following:

- Pencils, paper, rubber.
- Poster with pictures of the Earth and the Moon in different spectral ranges.
- A text about the Earth and the Moon in different spectral ranges.

Procedure

We are going to find out which image corresponds to which spectral range: radiowaves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays.

1. Take a close look at the pictures in the poster. We will start with the Earth and then we will see similar pictures about the Moon.

2. Each team gets a piece of the text about the Earth as seen in different spectral ranges.

3. Try to match each piece of the text with the picture it seems to describe. Why did you chose it this way?

4. Round table discussion: put together on top of the poster every piece of the text as you decided, and explain to the rest of the teams your reasons.

5. Repeat the procedure for the Moon case, and discuss the differences.

Results

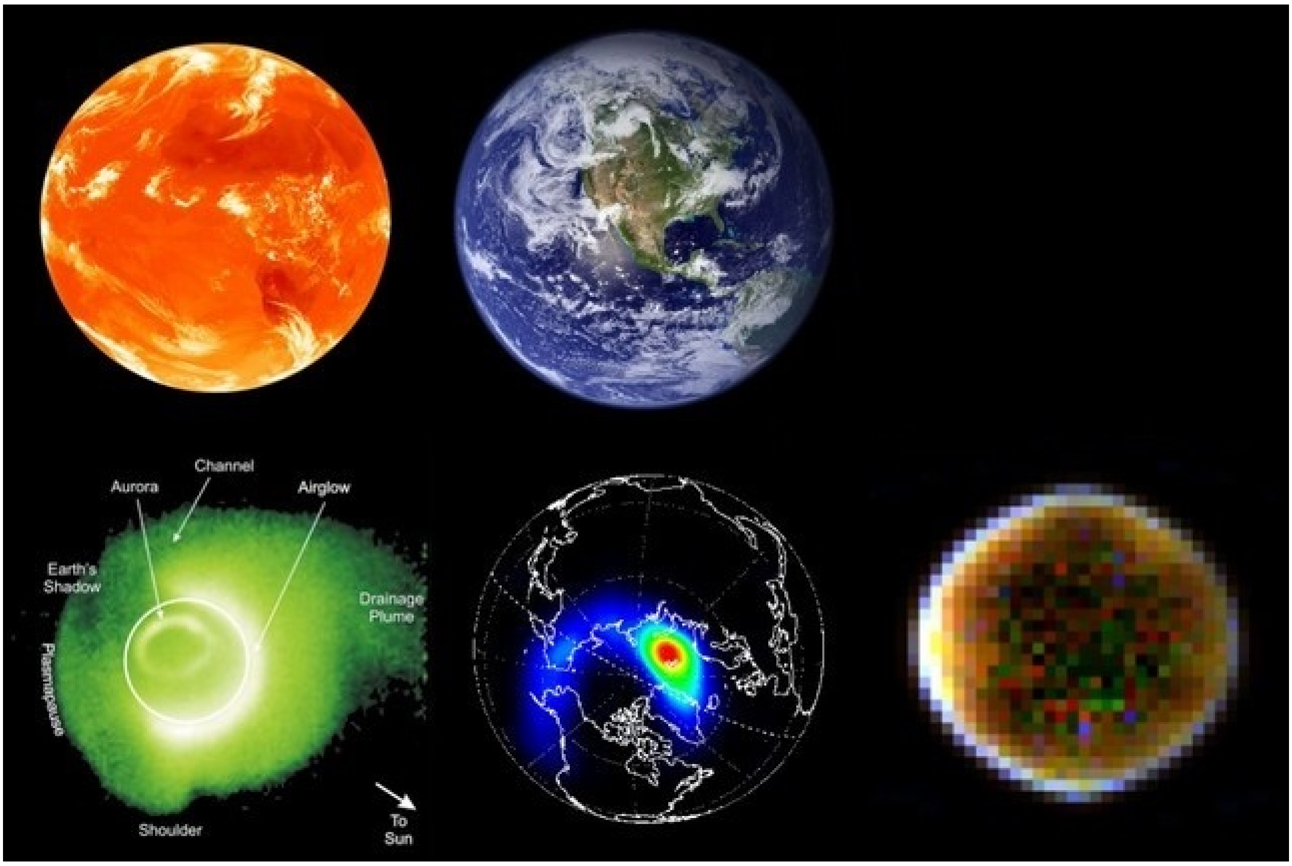
Conclusions

What can we learn from the whole set of pictures in different spectral ranges? Would you get rid of a particular range of the spectrum? Why?

In astrophysics, scientists usually work in different fields divided according to the electromagnetic spectrum: radiowave, infrared, visible... What do you think about this method? Could you propose another way of working?

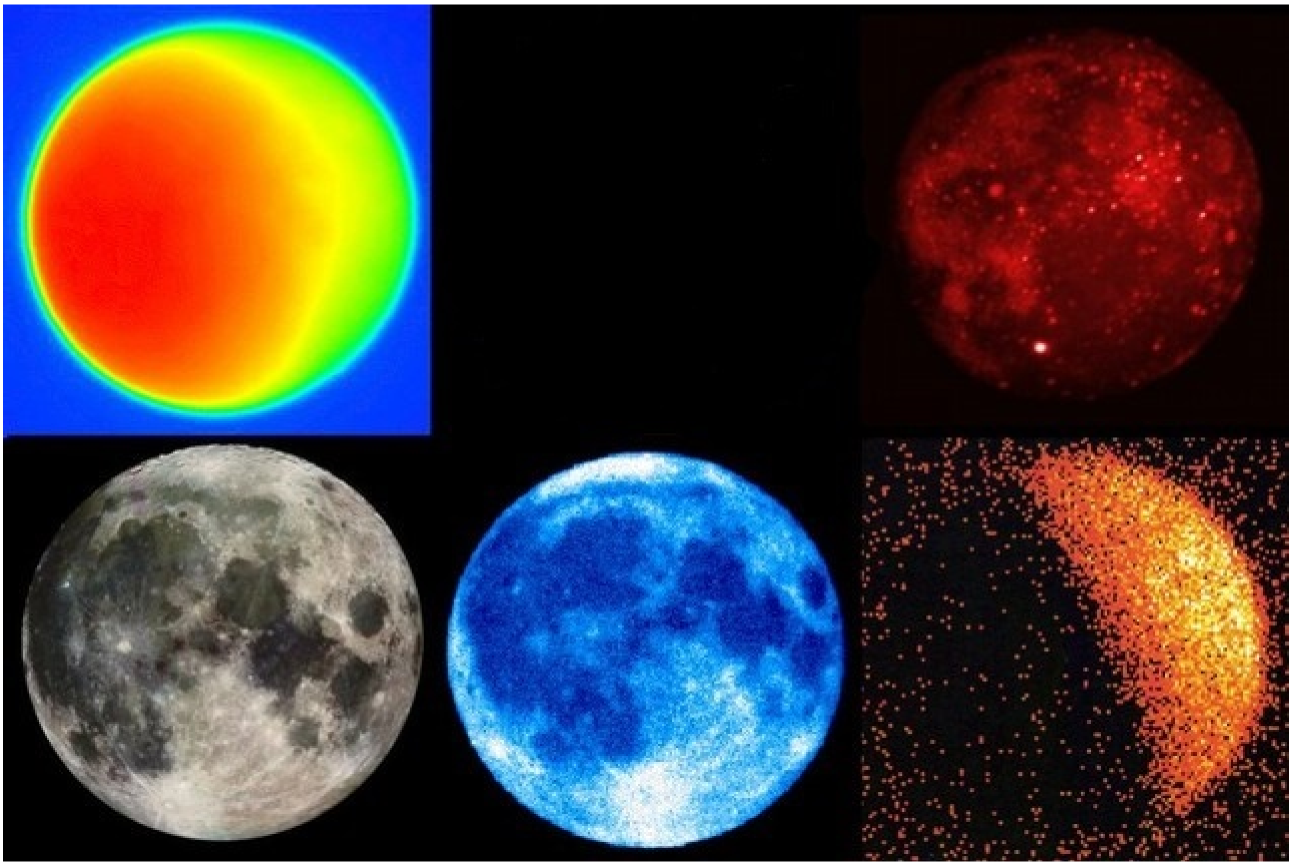
Research equipment

Pictures of the Earth in different spectral ranges



Credit: NASA

Pictures of the Moon in different spectral ranges



Credit: NASA

The Earth in different spectral ranges

When bodies are hot (above 0k) they emit infrared light. Water in the atmosphere absorbs infrared radiation, which is why we see our planet the way we see it in that range. This is also the reason why we place infrared telescopes outside of the atmosphere (such as ISO and Herschel), or in dry places at very high altitudes.

From visible light space telescopes (as those included in the ESA program called Copernico) we can see some of our planet's global phenomena: climate, oceanic currents, tectonic plate or iceberg movements, threats to ecosystems like big fires…

The Earth is in constant interaction with the Sun, particularly with solar wind, which is a series of currents made of charged particle that crash against our atmosphere and our magnetic field. The illuminated side of Earth is the one that receives more ultraviolet radiation. This energetic radiation travels at very high speed.

Moving now towards more energetic radiation, such as X-rays, we can get a more detailed view of phenomena such as aurora borealis (northern lights). Earth's magnetic fields has a north pole and a south pole, where charged particles from the Sun are deviated and collide at great velocities with molecules in our atmosphere. This can be seen as a halo, with zones of more intensity (aurorae).

Lastly, the most energetic radiation would be gamma rays, generated in big galaxies' nuclei, massive star explosions, and very dense objects, such as pulsars or black holes. Our planet is constantly bombarded by cosmic rays generated in these events. Luckily, both our atmosphere and our magnetic field protect us from their harmful effects.

Science case 2: Study of the Andromeda galaxy from different spectra

Procedure

We will now repeat the same steps [as in Case 1] to identify which part or range of the spectrum corresponds to each image from the Andromeda galaxy, or *M31*: radiowaves, far infrared, near infrared, visible light, ultraviolet, X-rays.

For a deeper study, you can also look for images of the galaxy with ESASky and you can analyse the information that you find on the web:
http://sky.esa.int/?action=goto&target=10.684708333333333%2041.268750000000004&hips=DSS2%20color&fov=3.981453126644165&cooframe=J2000

The Andromeda galaxy in different ranges of the spectrum

The Andromeda galaxy is a spiral galaxy, it looks as a whirpool when you look from above. Most of the stars and nebulae (clouds made of dust and gas) are concentrated in a thin disk, specially on the central bulb.

If you want to see the regions with dust and gas, which are usually obscured to the visible light, you need to take an image in the infrared part of the spectrum. Stars, and specifically those in formation phase, heat up the surrounding gas: the emission from this gas is in infrared. The region of hot gas and dust can be seen sharply thorough the disk in the near infrared.

The region from the electromagnetic spectrum known as “infrared” can be studied in two parts: near and far infrared. The images of the galaxies in far infrared show similar regions (clouds of gas and dust), but those regions are colder than in the near infrared images. In this particular case you are watching, those images are less sharp than the near infrared ones.

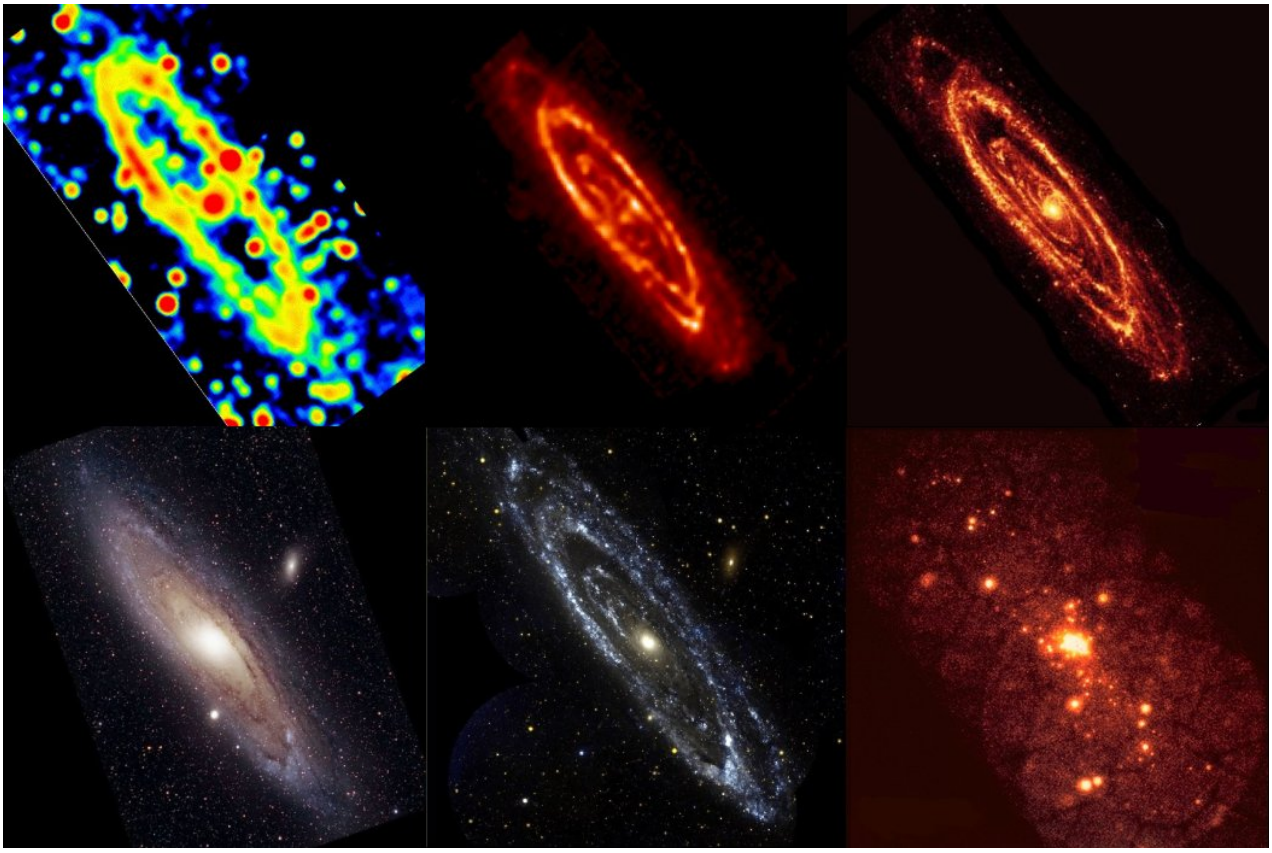
Images showing a galaxy in radiowaves look very different from the more regular ones in the visible part of the spectrum. For a start, the colours only show a scale of intensity: the redder, the more intense, followed by yellow, and so on, up to the darker areas where no radiation can be detected. The smaller detailes can not be seen in this particular image, although the general structure is shown (disk, central bulb…) Radiowave images are useful, among many other things, to draw magnetic field maps of the whole galaxy. The most energetic process in the universe are not only observed in X-ray or gamma-ray, but they are also detected in radio waves.

When you are watching an image of a galaxy in ultraviolet light, you can see a stricking resemblance with the same image in visible light. However, due to the detection techniques in this particular case, the whole image of the galaxy does not fit in one single shot: every small part has had to be puzzled together for the final image. Ultraviolet light is more energetic than visible light, and thus, younger stars, which are more massive and brilliant, can be located with ultraviolet images.

The more violent processes of the universe are traced by X-rays and gamma-rays. An image of a galaxy in X-rays does not show the disk, but specific and compact areas. Those areas corresponds to stellar explosions or supernovae, stellar wind shocks, jet-like emissions from pulsars, black holes (like the one sitting at the center of most galaxies), etc.

Research equipment

Images of the Andromeda galaxy (*M31)* in different ranges ot the spectrum



Credit: NASA