

Scanning Across the Spectrum

Overview: We're going to use some software developed by the European Space Agency (ESA) to view data of distant galaxies. We'll be able to switch between different wavelengths to see different parts of the galaxy light up. At first your goal will be to explore two galaxies using different kinds of wavelengths and take notes and photos of what you find. In the second half of the assignment, you'll be tasked to summarize your findings as you describe the two galaxies, and then compare and contrast what makes the galaxies different. Part of the goal today is to deliberately practice your writing skills, so expect to put in effort to write a couple paragraphs today.

Part 1: We are going to use software made by the ESA to view different galaxies using photographs from a variety of types of telescopes. We will focus on two Galaxies today: M 31 (young galaxy) and M 87 (old galaxy) to see how the galaxies have different shapes, but also because of their age difference they have different types of stars spread throughout them. **For each galaxy you will use a variety of types of light to investigate what stars make up the galaxy and record this using a screenshot and a description.**

1. Open up this link here: <https://sky.esa.int/esasky/>
2. Then click **EXPLORER**
3. Use the table below to help you make sense of what you see in the photographs.

Types of Light and Objects that Produce Them		
Type of Light	Temperature (K)	Typical Sources
Gamma Rays	$> 10^8$ K	Matter falling into Black Holes
X-rays	$10^8 - 10^6$ K	Supernovas
Ultraviolet	$10^6 - 10^4$ K	Very Hot (and young) Stars
Visible	10000 - 1000 K	Cool (medium to old) Stars
Infrared	200 - 1000 K	Cool Dust and Stars Forming
Microwaves	10 - 200 K	Cosmic Microwave Background
Radio	< 10 K	Extremely Cold Dust

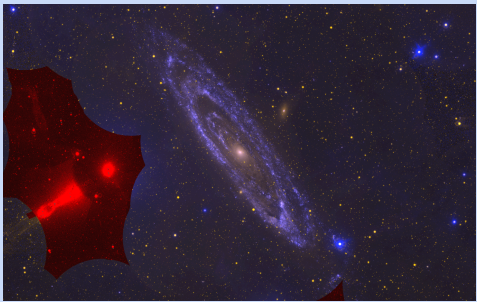
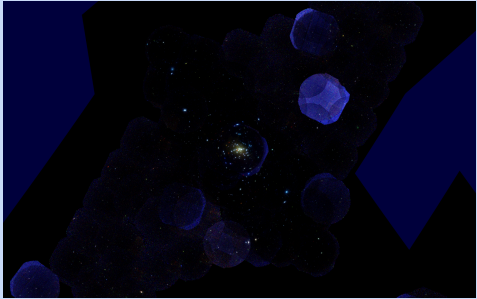
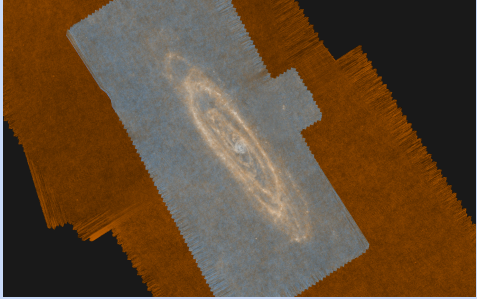
4. For Both galaxies use the software to view the galaxies using the following types of light. Switch between the types of light by clicking the icon in the top left corner which is three colored diamonds. Click the drop down menu on the left and select the light setting you are looking for.

Light Setting in Software	Part of EM Spectrum
Optical	Visible Light
Ultraviolet	Ultraviolet
Soft X-ray (M87 will need to zoom out)	X-rays (lower energy)
Far Infrared	Infrared (lower energy)

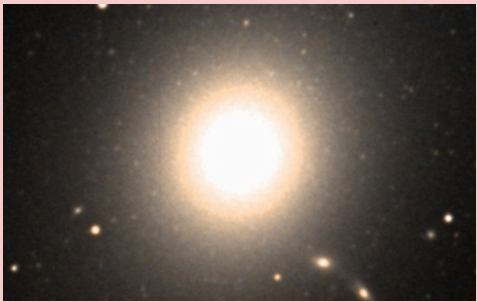
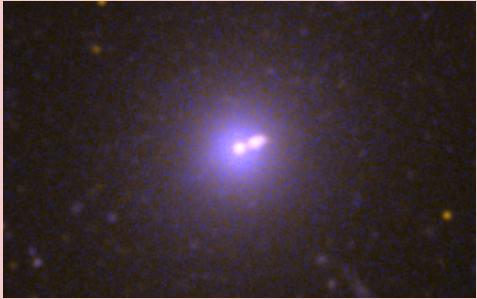
5. For each galaxy and type of light:

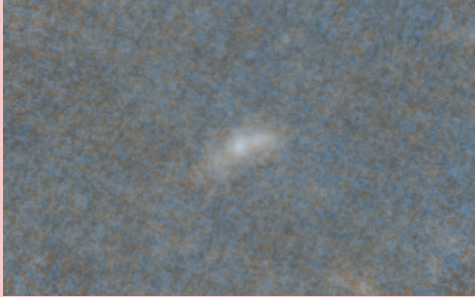
- Get a screenshot with the camera icon (like this ) in the top right corner. **And then upload it into this document.**
- Describe with your words where that type of light is showing up in the galaxy
- Describe with your words what type of objects are the likely source of the light (table above to help)
- **And in the visible light section**, describe the shape and overall look of the entire galaxy

M 31 - Spiral Galaxy - Younger galaxy		
Type of Light	Screenshot of the Galaxy	Description
Visible		Describe the Galaxy and where this light is coming from. The galaxy has most of its visible light coming from the center, and less light is coming from the edges. Describe what kinds of objects are a source for this light. Because this is visible light, the sources of the light are coming from older, and cooler stars, with most of the older stars clumped up towards the center.

Ultraviolet		Describe the Galaxy and where this light is coming from. The galaxy has less UV light, and most of the light is towards the edge. Describe what kinds of objects are a source for this light. Because we are looking at UV light, the source of the light is coming from young, hot stars.
X-rays		Describe the Galaxy and where this light is coming from. There is very little X-ray light coming from the galaxy, but the little light that is being produced is towards the center. Describe what kinds of objects are a source for this light. X-ray light is produced by supernovas. The incredibly hot and old parts of the galaxy.
Infrared		Describe the Galaxy and where this light is coming from. Infrared light is being emitted from all of the galaxy, with not one single outlier spot with more or less infrared light. Describe what kinds of objects are a source for this light. Infrared light is observed from cool dust and forming stars, so there's forming stars and dust everywhere in the galaxy.

M 87 - Elliptical Galaxy - Older galaxy		
Type of Light	Screenshot of the Galaxy	Description

Visible		Describe the Galaxy and where this light is coming from. The galaxy has a high contrast of visible light towards the middle. Describe what kinds of objects are a source for this light. Because we're looking at visible light, the sources of the light is coming from cooler, middle to old, stars.
Ultraviolet		Describe the Galaxy and where this light is coming from. The galaxy has very little UV light being emitted, and the little light is centralized at the middle. Describe what kinds of objects are a source for this light. Because we are looking at UV light the, the source of the light is being emitted from very hot and young stars, so this galaxy has a small amount of young stars, all at the center of the galaxy.
X-rays		Describe the Galaxy and where this light is coming from. The galaxy is emitting a ton of X-ray light, like the whole galaxy is emitting it. Describe what kinds of objects are a source for this light. X-ray light is emitted from supernovas that are extremely hot, so this galaxy either blew up, or is just extremely hot.

Infrared		Describe the Galaxy and where this light is coming from. The galaxy has very little light that is being emitted from the center of the galaxy, but it's very fuzzy. Describe what kinds of objects are a source for this light. Infrared light is emitted from cool dust and forming stars, so this galaxy is no-longer producing stars, with little cool dust.
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Part 2: In this section you will write about three paragraphs. I want you to summarize with your words what you found above about each galaxy. So one paragraph per galaxy. Then in your third and final paragraph compare and contrast what makes the two examples different. Try to show what appears to change as a young galaxy (M 31) ages into an old galaxy (M 87). At this point you have all the data you need to start, you just have to summarize what you have found and explain what makes the galaxies different.

I've found out that the younger galaxy (M 31) is a cooler galaxy and has a high contrast in all light except for X-ray light. M 31 has a high contrast in visible light, UV light, and Infrared light. On the other hand, M 31 has a low contrast in X-ray light. Towards the center of the galaxy, there are older and cooler stars ($10000 - 1000$ K), so the center of the galaxy is emitting a lot of Visible light that looks very bright. Towards the outer edges of the galaxy are younger and hotter stars ($10^6 - 10^4$ K), so the outer edge emits a lot of UV light. Throughout the whole galaxy, there are stars forming everywhere, and it has a lot of cool dust ($200 - 1000$ K), so the galaxy emits a lot of Infrared light. The galaxy has one type of light that is not being emitted a ton: X-ray light. It's emitted from supernovas that are extremely hot ($10^8 - 10^6$ K). Although there is X-ray light being emitted from the center of the galaxy, there is a very low contrast of that light compared to the other types of light, so I can conclude that this galaxy is on the cooler end—as it is, of course, a younger galaxy.

I've found out that the older galaxy (M87) is an extremely hot galaxy and has a high contrast of Visible and X-ray light. On the other hand, M 87 has a low contrast of UV and Infrared light. Towards the center of the galaxy, or the whole galaxy, there are older and cooler stars ($10000 - 1000$ K), so the galaxy is emitting a lot of Visible light that is very bright. At the center of the galaxy are a couple of younger and hotter stars ($10^6 - 10^4$ K), so the center emits very little UV light. Throughout the galaxy, there are few to no forming stars, and it has a very small amount of cool dust ($200 - 1000$ K), so the

galaxy emits little to none Infrared light towards the center. The galaxy has one type of light that stands out, and emits a ton of; X-ray light, it's emitted from supernovas that are extremely hot ($10^8 - 10^6$ K), there is X-ray light being emitted from the whole galaxy, there is a very high contrast of that light compared to the other types of light, so I can conclude that this galaxy is on the hotter end—as it's the older galaxy.

I've found that as a galaxy gets older, it gets hotter and brighter, and the shape of the galaxy gets more spherical and less disc-like. The cooler objects emitting or letting Infrared light through, as seen from M 31, aren't seen in M 87, as there is little to none. As the galaxy gets older, visible light gets brighter and gets more compact towards the center; this is seen with M 31, which doesn't have bright visible light towards the center and the visible light is spread out throughout the galaxy, and M 87 has all of its visible light clumped towards the center and is very bright. The UV light that's being emitted from M 31 is the complete opposite compared to M 87. M 31 has its UV emitting throughout the whole galaxy as it's young, with an uncountable amount of young stars, whilst M 87 has only two bright objects emitting UV at the center of the galaxy. The last, but certainly not the least. The light that's emitted from both galaxies: X-rays. X-ray light shows the greatest difference between M 31(young) and M 87(old). In M 31, there is a very small number of supernovas that emit X-ray light, and on the other hand, M 87 is just a supernova emitting X-ray light—I can't see anything else but green. I can conclude—just from the X-ray light that's emitted from M 87—that the older a galaxy gets, the hotter, and as a galaxy gets older the objects get pulled towards the center; the shape of the galaxy gets more spherical and less disc-like.