ROYAL OBSERVATORY GREENWICH

# Colour and Wavelength in Space
## Key Stage 4

**Topics covered:** electromagnetic spectrum, waves, Sun, Milky Way, multi-wavelength astronomy

**Teacher's Notes**

In this activity, students look at the Sun and the Milky Way in different wavelengths. They revisit the electromagnetic spectrum and apply their understanding of its properties to astrophysical objects and why it is important to use the whole spectrum in astronomy.

**Equipment:** computer

**Questions to ask the class before the activity:**

What is a spectrum?
Answer: a 'fingerprint' of an object made of light. The spectrum of visible light is composed of the colours of the rainbow.

What are the different parts of the electromagnetic spectrum?
Answer: gamma ray, X-ray, ultraviolet, visible, infrared, microwave, radio

How do these different types of light differ?
Answer: they have different wavelengths or frequencies which give them different energies e.g. gamma rays have a short wavelength, a high frequency and a high energy, radio waves have a much longer wavelength, a low frequency and consequently a low energy.

**Questions to ask the class after the activity:**

What would X-rays and gamma rays do to us? If the Sun emits (high energy) X-rays and gamma rays why did life evolve on Earth?
Answer: high energy radiation damages our DNA and our cells, we would become very ill and eventually die from exposure to this radiation. Life has survived on Earth because we have an atmosphere that protects us from this radiation.

Why do we have telescopes for the whole of the electromagnetic spectrum and not just for optical light?
Answer: we can't see everything with just optical light, often this light is blocked by dust or there are regions in space that do not emit optical light but appear bright in other wavelengths.

**Colour and Wavelength in Space: Answers**

Satellites such as Yohkoh, SOHO (Solar and Heliospheric Observatory) and terrestrial telescopes such as the McMath-Pierce telescope on Kitt Peak in Arizona have imaged the Sun in X-ray, ultraviolet and infrared light. Which image shows the shortest wavelength and which is the longest?
Answer: X-ray light has the shortest wavelength, infrared is the longest.

Look at the three images of the Sun. Describe the differences and similarities between them.
Answer: the dark patches in the X-ray and UV images are bright in the IR (these are called coronal holes, regions in the Sun's outer atmosphere - the corona where magnetic field lines burst through). The dark features in the IR image are bright in shorter wavelengths. There is absorption of IR light by the gas in these regions.

Examples of solar filters are the hydrogen alpha (Hα) which transmits a wavelength of 656.3 nm, the sodium D, wavelength = 589 nm and calcium K filters, wavelength = 393 nm. What colour would the Sun appear through these filters?
Answer: through the Hα filter the Sun is red, Na D is yellow and Ca K is blue.

Describe the differences between the images (of the Milky Way) taken in different regions of the electromagnetic spectrum.
Answer: in the X-ray and visible the Milky Way appears dark with brighter regions above and below, particularly in the X-ray. In contrast the galaxy is very bright in gamma ray and in the opposite region of the electromagnetic spectrum at the longer wavelengths of infrared to radio – here vast diffuse bright regions can be seen around the galaxy.

Why do you think the Milky Way looks so different in different wavelengths? Think about the energies of the different wavelengths.
Answer: there is a lot of dust in the Milky Way which blocks visible light from reaching us, however high energy (short wavelength) and low energy (long wavelength) light can penetrate this dust thus our galaxy appears brighter in these wavelengths. Also there is a lot of gas in the Milky Way at a large range of temperatures (and different energies) thus emerging different wavelengths of light.

Why is it important for astronomers to look at objects in space in all wavelengths?
Answer: so we don't miss anything! Features we can't see in visible light we can see in other wavelengths, this way we get a complete picture of the object we are studying.

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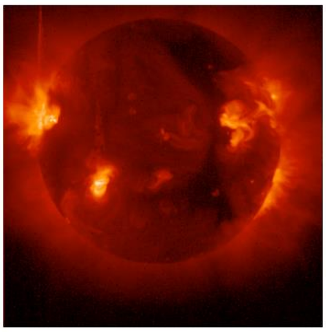
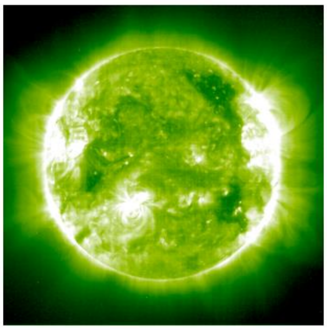
# Activity: Colour and Wavelength in Space

The Sun appears yellow in colour in visible light. We cannot see the Sun in wavelengths outside of the visible region of the electromagnetic spectrum with our eyes however we can build detectors and telescopes that respond to light of other wavelengths. The Sun looks very different in other wavelengths (below). These have been artificially coloured so that we can see them. Satellites such as Yohkoh, SOHO (Solar and Heliospheric Observatory) and terrestrial telescopes such as the McMath-Pierce telescope on Kitt Peak in Arizona have imaged the Sun in X-ray, ultraviolet and infrared light.

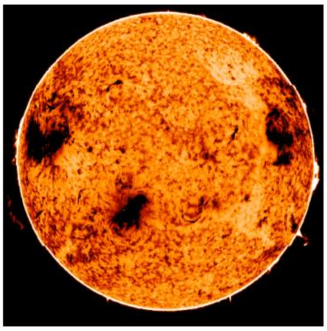
Which image shows the shortest wavelength and which is the longest?



X-ray: Yohkoh



Extreme UV: SOHO

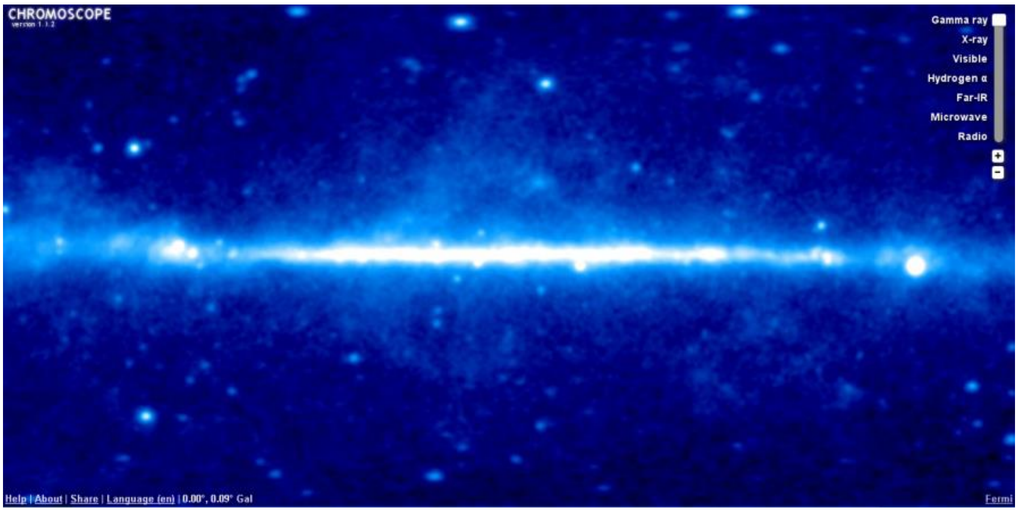


Infrared: NSO McMath-Pierce

Look at the three images of the **Sun**. Describe the differences and similarities between them.

A solar filter transmits specific wavelengths of light. Examples are the hydrogen alpha (Hα) which transmits a wavelength of 656.3 nm, the sodium D, wavelength = 589 nm and calcium K filters, wavelength = 393 nm. What colour would the Sun appear through these filters?

The **Milky Way** looks very different in different wavelengths. Go to http://www.chromoscope.net/(next page) and **describe** the differences between the images taken in different regions of the electromagnetic spectrum.




Why do you think the Milky Way looks so different in different wavelengths? Think about the energies of the different wavelengths.

Why is it important for astronomers to look at objects in space in **all** wavelengths?