Chapter 4: Multiwavelength Universe

Student Worksheet

Objective:

Explore the electromagnetic spectrum. Explain the uses of multiwavelength observation in astronomy. Distinguish images in different wavelengths of light.

Engage:

Can you explain the differences in the infrared photos below?

Figure 1 (a) NASA/IPAC

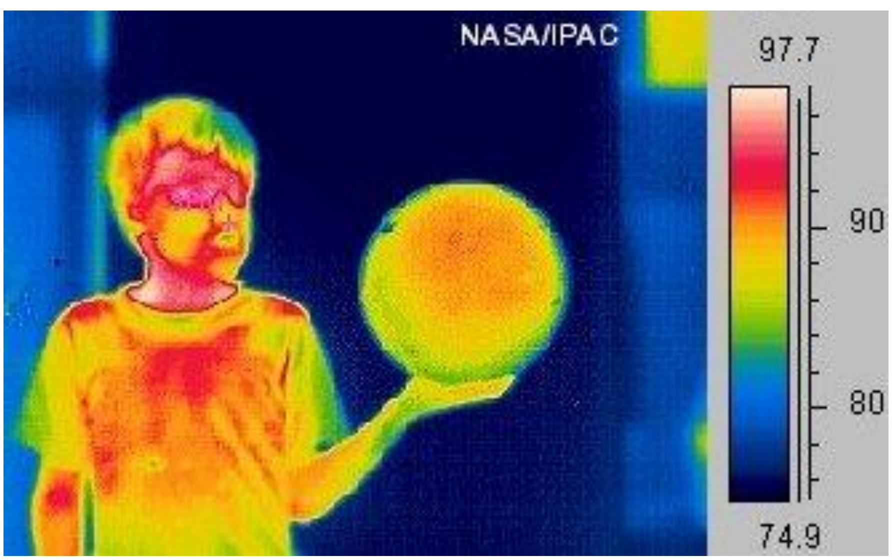

Figure 1 (b) NASA/IPAC

Introduction:

In this activity you will learn what can be seen with telescopes that cannot be seen with the eye. You will learn how studying an astronomical object in many different wavelengths of light gives a much larger understanding of the object than just seeing it in visible light. You will begin by looking more closely at the electromagnetic spectrum. Imagine how much more we could know about our surroundings if we could see the entire spectrum, or even just a bit more. You will also learn about different telescopes that see in different parts of the spectrum. Comparing pictures in different parts of the spectrum can give us a lot of information about an object. You will match photos of the same object taken in different wavelengths. Finally you will put yourself to the test with some applied problems.

Background:

- Examine the electromagnetic spectrum in Figure 2 below. Notice:
  - The range of light we see
  - The types of light that penetrate our atmosphere
  - The relationship between temperature and wavelength
  - The relationship between wavelength and frequency

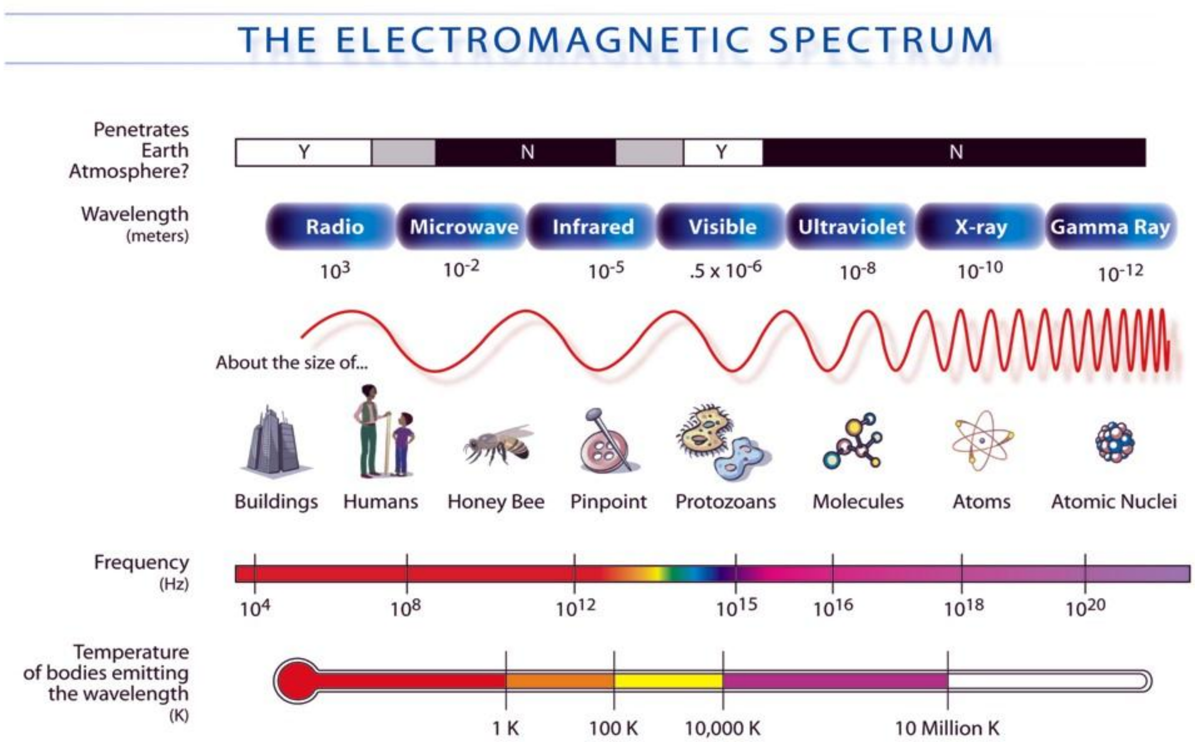

Figure 2 NASA

- As you can see in the top band of Figure 2 (the electromagnetic spectrum chart), only some of this light reaches Earth because our atmosphere blocks much of it. Many astronomers think of our atmosphere as nearly opaque, due to the inability of so many wavelengths of light to get through to the Earth's surface.
- The chart in Figure 3 below shows where in the atmosphere different types of light are blocked or transmitted by our atmosphere. Study it to see which types of light get in, and which do not.

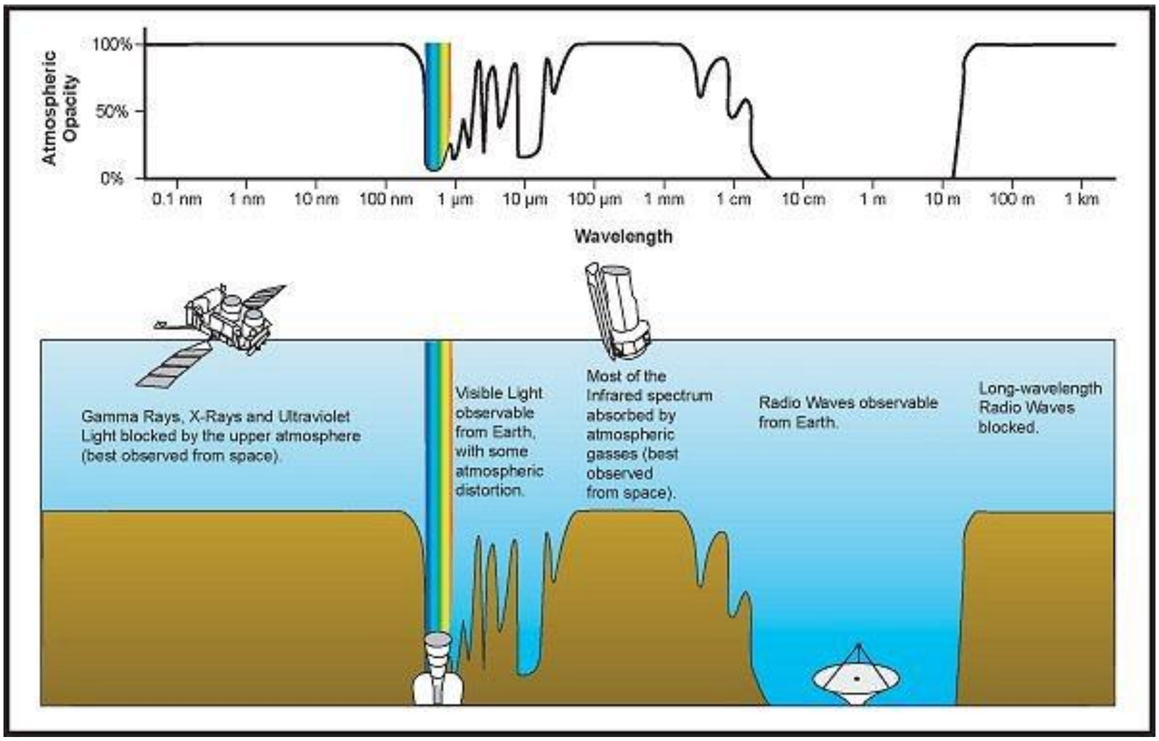

Figure 3 Atmospheric Windows NASA/IPAC

- Because much of the light in the universe does not penetrate Earth's atmosphere, we have telescopes above the atmosphere to see it. Helium balloons, high-flying airplanes, and orbiting satellites are all examples of ways to collect light in a telescope above the atmosphere.

- In each range of the electromagnetic spectrum different astronomical features are seen. Study Table 1 below to gain a sense of which features of astronomical objects are seen in each region. Bookmark this in your mind, knowing these trends will be useful to you for the duration of your astronomy education.

Range of Electromagnetic Spectrum	Prominent Features
Radio	Active galaxies, some stars (particularly binary stars), supernovae, pulsars, and clouds of cold molecular hydrogen gas are typical emitters of radio waves.
Infrared	Dust blocks visible light, but infrared light can pass through dust to reveal what is inside. Cool, dim stars and dust are visible in the infrared range.
Visible	We see large and bright stars in our galaxy, nebulae, supernova remnants, planets, and galaxies in the visible range.
Ultraviolet	In the ultraviolet range, we see hot stars in our galaxy, and quasars in other galaxies. Gas that has been heated to a million degrees can be seen in the ultraviolet range.
X-ray	An object shines in x-rays if it is very hot (millions of degrees). High temperatures can be reached in the presence of magnetic fields or extreme gravity, or events such as supernovae can heat surrounding material. Hot interstellar gas, neutron stars, and supernova remnants are some objects that are studied in x-rays.
Gamma	Gamma rays are produced by changes in atomic nuclei. They are also products of collisions between cosmic rays and interstellar matter. The objects and phenomena most often studied in gamma rays include neutron stars, quasars, black holes, and gamma ray bursts.

Table 1

- In Figure 4 below are three photos of Cassiopeia A, a supernova remnant. The image on the left is taken in the x-ray range of the electromagnetic spectrum, the image in the center is taken in visible light, and the image on the right is a radio image. Note how with an understanding of the features visible in each region of the electromagnetic spectrum we can gain a lot of insight as to what is going on in this supernova remnant. Much more than meets the eye!

Figure 4: Cassiopeia A NASA/CXC/SAO

- Now you are ready to begin your matching activity.

Procedure:

1. You and your partner will receive 3 sets of cards. These sets of cards contain images of 6 different galaxies. Each galaxy is photographed 3 times: in infrared, visible, and x-ray light. Your job is to match the galaxies and then complete Table 2 below. Begin with matching the visible to the infrared. Make sure to look again at Table 1 above for guidance.

2. In Table 2 below, record the letter of the infrared galaxy to match with the number for the visible galaxy.

3. Put the infrared cards away. Keep the visible cards on the desk.

4. Match the visible cards to the x-ray cards. Record the roman numeral of the x-ray galaxy to match with the number for the visible galaxy in the table below.

5. Now bring the infrared cards back to the table. Look at your matches with all of the cards present. In Table 2, make and record any changes to your matching scheme.

6. Check your results with your instructor.

Infrared Galaxy Letter	*Visible Galaxy Number*	*X-Ray Galaxy Roman Numeral*	*Actual Galaxy Name (given at the end with the solution)*
EX: G	*9*	*III*	

Table 2

Conclusion:

1. As the wavelength of light emitted by an object increases, how does the energy of the light change? How does the temperature of the object change?

2. How do temperature and color relate? Is a red star hotter or cooler than a blue star?

3. You are given the following observing targets:
    a. A cold cloud of gas and dust
    b. A recent supernova remnant
    c. A globular cluster of stars

    Choose which region of the electromagnetic spectrum you would like to use to observe each object. Explain your choices.

4. We used infrared images from the Spitzer Space Telescope. It makes sense to have infrared telescopes in space. There are however, a few infrared telescopes on Earth. Describe how and where this might be possible.

Extend:

- Visit NASA.gov and search for the Tour of the Electromagnetic Spectrum booklet.
- Create a poster of astronomical images captured in different light.
- Research the telescopes used by astronomers in different wavelengths. NASA's Great Observatories Project is a good place to begin your research.