Infrared and Visible Images

Purpose:
The purpose of this activity is for students to make their own three-color astronomical image using visible and infrared part of the spectrum. They are to compare and contrast the differences in each image made.

Key Science Topics:
- The electromagnetic spectrum

Grade Level:
- Physics, Grades 11-12
- May be modified for an upper-level art or computer graphics course

Student Prior Knowledge:
- Students should know the parts of the electromagnetic spectrum and characteristics of each.
- Students should know that when discussing the electromagnetic spectrum, “redder” means longer wavelength and “bluer” means shorter wavelength.
- Students should know that combining red, green, and blue light produces white light.
- Photons are packets of light.

Materials:
- One computer per student or pair of students.
- DS9 free image manipulation program.
- Power Point Slide of the Orion Nebula in visible and infrared wavelengths. The image is provided in the student handout, but is included in a Power Point as it may be cost prohibitive to print the student handout in color.

Background:
The DS9 image display program can be downloaded at no cost from the following website: http://chandra-ed.harvard.edu/install.html.

There are many wonderful educational tools and resources at the Chandra Education Data Analysis Software and Activities (http://chandra-ed.harvard.edu/index.html). There is a lesson on how to make three-color images using a few selected images from Chandra’s database. The user is limited to only those objects and must download another program, ImageJ, to produce the final image. This lesson describes how to make a three-color image using only DS9.

Deliverable:
- 1 3-color visible image
- 1 3-color infrared image

Resources:

For more information on using DS9, please visit the following DS9 tutorials by Dr. Luisa Rebull, research astronomer at the Spitzer Science Center/IPAC/Caltech.

Part 1:
http://www.youtube.com/watch?v=C8QBwrKbEtc

Part 2:
http://www.youtube.com/watch?v=Z1zic8msSM0

Part 3:
http://www.youtube.com/watch?v=vVwW-8h2drw

Student Handout

Infrared and Visible Images

Name:______________________________________ Date:_____________

Purpose:

Background:

The Primary Colors

You probably remember your elementary art class teacher stating the three primary colors are red, yellow, and blue. You may have been assigned the task of blending combinations of red, yellow, and blue water colors or clay to make orange, green, and purple—the secondary colors. Did you ever notice that no matter how hard you tried, the colors never turned out well? For example, purple was always too red or too blue and never matched the crayon. That is because red, yellow, and blue are not primary colors.

Next time you are at the office supply store, look for a package of colored ink for an ink-jet printer. The colors included in the box are not red, yellow, and blue, but magenta, yellow, and cyan. Magenta, a dark pink color, yellow, and cyan (also known as blue-green or aqua) are the three primary *pigment* colors.

However, when your physics teacher asks what the three primary colors of light are, magenta, yellow, and cyan are not the correct answer. Red, green, and blue are the primary colors of light. If these three colors are combined, white light is produced. Our eyes have two types of cells which detect light, called photoreceptors. The two types of photoreceptors are rods and cones. The rods are sensitive to intensity of light, but cannot detect color. The cones are sensitive to color. There are three types of cones; one type for each of the primary colors, red, green, and blue.

Color Images

There is no such thing as a color photograph. All photographs, whether on film or digital, are grayscale.

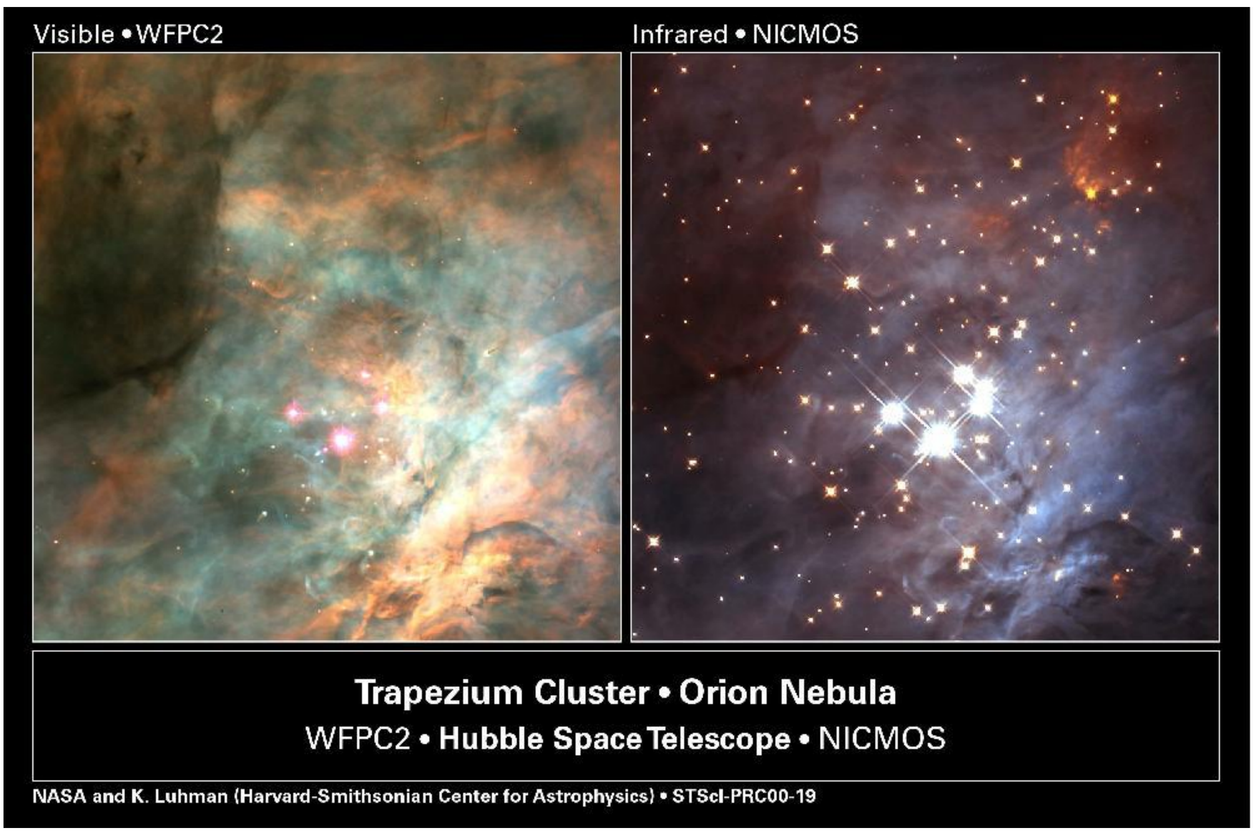
That's quite a statement, so let's think about this. We all know the first photographs were called black and white, but are more correctly called grayscale. But we also know we can go to a kiosk, insert the digital memory card disk, and within minutes, the machine prints beautiful color images.

The fundamental process for producing color photographs was first proposed by James Clerk Maxwell in 1855. In film photography, light is passed through the camera lens and is focused on film with emulsion layers that are sensitive to red, green, and blue light. The resulting image is in color. Making digital color prints is similar. Instead of emulsions, digital cameras detect the energy of incoming particles of light, or photons and separate those photons by the amount of energy they have. Higher energy photons are assigned to be blue, lower energy photons are red, and photons with a moderate energy are green.

Astronomers do the same thing when making three-color images. They assign images taken at a shorter wavelength (higher energy) blue, images taken at longer wavelengths (lower energy) red, and intermediate wavelengths green. These images may use only images from one part of the spectrum, or may combine parts of the spectrum.

In this activity, you will be making two three-color composite images using DS9. One image will use infrared data and the other image will use visible data.

Part 1: Optical vs. Infrared Images
Below are two images of the same object. The object on the left is taken in the part of the spectrum visible to the human eye. The object on the right is taken in the infrared part of the spectrum.



1. What is similar in both images of the Orion Nebula?

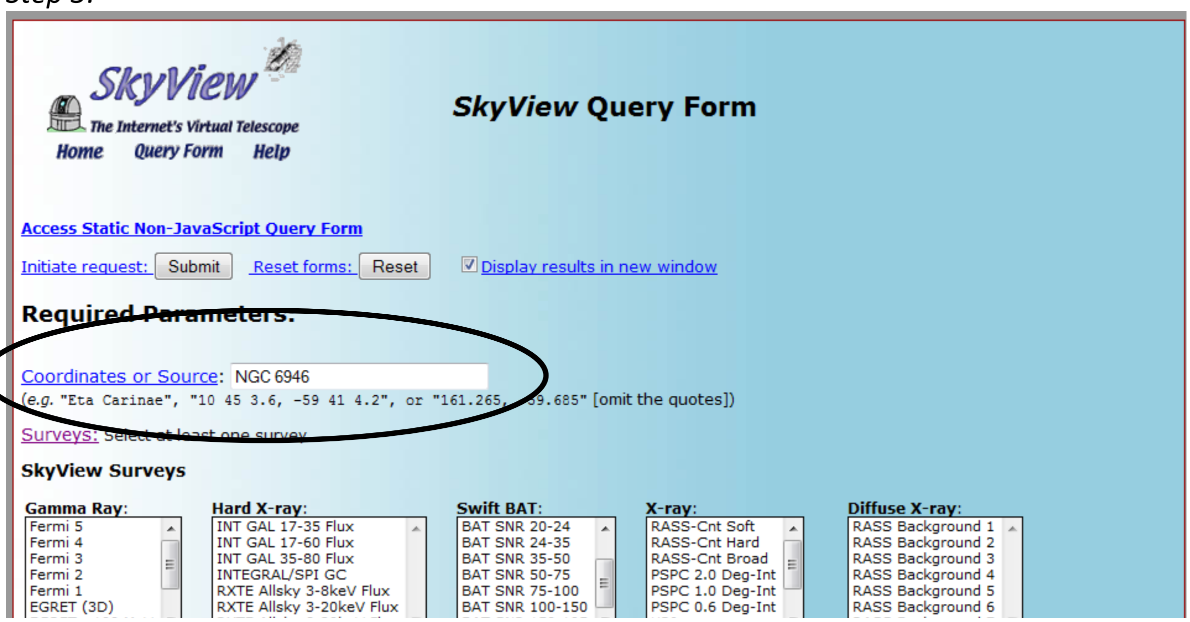
2. What is different in the images of the Orion Nebula?

3. Why might astronomers look at the same object in different wavelengths?

Part 2: Getting the Optical Images

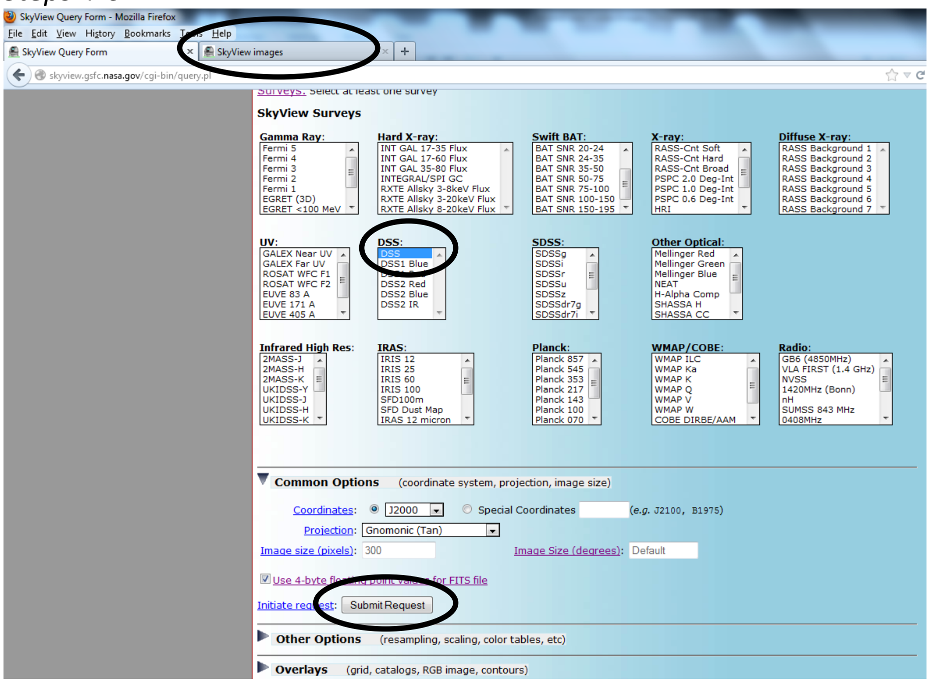
1. Go to the Goddard SkyView website: http://skyview.gsfc.nasa.gov/
2. Scroll down and select, "SkyView Query Form" and you will be presented with a page with lots of choices.
3. Enter the name of the object, e.g., "NGC 6946," the "Crab Nebula," etc, without quotes in the Coordinates or Source Box. For this example, NGC 6946 will be used.

Step 3:



4. Next, select an optical image. The DSS Survey will be used.
5. Select “DSS,” then “Submit Request.”
6. Your image will appear in a new tab. Click on the “SkyView Images” tab to see your image.

Steps 4-6

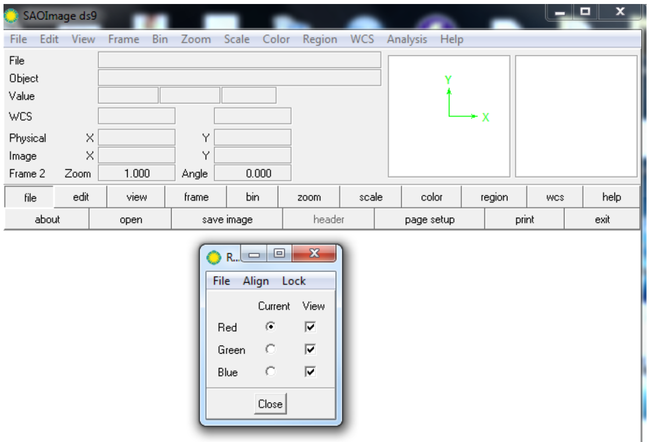


7. Select “download FITS” and save file as NGC6946green in a folder you will be able to access.

8. Repeat the process and download the DSS red and blue files for NGC6946.

Part 3: Making the RGB (three-color) image using DS9.
DS9 is an image processing tool. There are other image processors available—feel free to experiment!

1. Open DS9 on your computer. To begin, go to **Frame** and select **New Frame RGB.**
2. A small window will pop up. Feel free to move the small window off to the side. Your screen will look like this:



3. On the small window, **Red** is automatically selected. Since red is selected, let's open the red image of NGC 6946. Go to **File** (on the big DS9 window), then **Open** and select the red image for NGC 6946. You should now have a red image in your window!
4. Next, in the small window, select **Green.** Now go back to the large window, go to **File**, then **Open** and select the green image for NGC6946.
5. ✓ You should now have an odd-colored image. The green image should be on top of the red image. If you have a separate green and red image, delete the extra green frame, and re-open the green image after reading the directions again. This is a very easy mistake to make!
6. What color is produced when green light is added to red light? ______________
   Do you see this color in your image? _________________
7. In the small window, select **Blue.** In the large window, go to **File**, then **Open** and select the blue image for NGC6946.
8. Now, you should have a three color (or RGB) image of NGC6946! If you would like to save this file, go to **File**, **Save Image**, and name your image. Be sure to add the .jpg extension to your file name. If this does not work, you can always take a screenshot (Ctrl + Prt Scr) and save that as a .jpg.
9. If you have time, play around with the "scale" of the image and see how the colors change.
10. If a star appears white on your image, that means it must be emitting what color combination (circle all that apply)? **RED** **GREEN** **BLUE**
11. What color is the center of the galaxy? ___________________________
12. What color are the spiral arms of the galaxy? ________________________

Congratulations on your successful visible image of NGC6946!

Part 4: Making the Infrared Images of NGC6946

1. To make an RGB infrared image of NGC6946, we need to get three images from Goddard SkyView.
2. In the **Infrared High Res** Column, you are going to use the J, H, and K bands. A J-band filter allows light with a wavelength of 1.25 µm (or 10^{6}m) to pass through and be digitally recorded. An H-band filter is corresponds to 1.65 µm, and the K band corresponds to 2.17 µm. In the table below, write which color each band will correspond to. Before proceeding, have your teacher check your color choices.

Filter	Wavelength	Color
J-band	1.25 µm	
H-band	1.65 µm	
K-band	2.17 µm	

3. Download the .fits files for the J, H, and K band images of NGC6946. Be sure to be descriptive in your file name and note whether the image is J, H, or K and/or if it is supposed to be red, green, or blue.
4. Once you have all three images saved, create an RGB image in DS9 and save the image as a .jpg.

Final Thoughts…

1. How are the infrared and visible images of NG6946 similar?

2. How are the infrared and visible images of NG6946 different?

Optional Questions…

3. Based on the visible image of NGC6946, how would you classify the galaxy (circle one)?
   SPIRAL **BARRED SPIRAL** **IRREGULAR** **ELLIPTICAL**

4. Based on the infrared image of NGC6946, how would you classify the galaxy (circle one)?
   SPIRAL **BARRED SPIRAL** **IRREGULAR** **ELLIPTICAL**

5. Did your classification of NGC6946 change? Why or why not?