National Aeronautics and Space Administration

Spitzer

The Milky Way

This is one segment of an infrared portrait of dust and stars radiating in the inner Milky Way. More than 800,000 frames from NASA's Spitzer Space Telescope were stitched together to create the full image, capturing more than 50 percent of our entire galaxy.
Credit: NASA/JPL-Caltech/University of Wisconsin.

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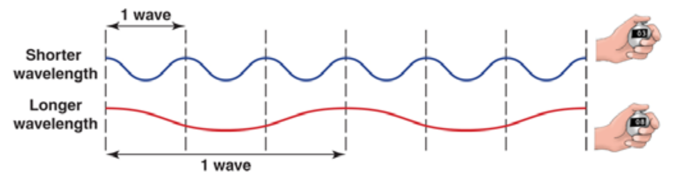
The Art of Space Imagery

Invisible colors of light

Colors are the way human eyes (and the brain) interpret different energies of light. There is nothing fundamentally different about the light the human eye can detect from the "light" used to see inside your body (X-rays) or the "light" used to communicate using your cell phone (microwaves). The only difference in these kinds of light is their energy. We can measure the energy of the light very accurately by examining either the light's wavelength (the distance from peak to peak of a light wave, much as peaks on a ripple of water) or its frequency (how many wave peaks pass a fixed location each second).



It's important to remember that our eyes are sensitive to only a very small portion of all possible light energies. There are lots more "colors" all around us and in the universe than the ones we can see.

The image of the Milky Way on the front of this poster is like a work of art, with beautiful red, green, yellow, and blue hues. But the Spitzer Space Telescope, which made this image, detects light in the infrared part of the spectrum. We shouldn't be able to see this image at all with our poor "visible light only" vision! Obviously, something had to be done to these images so humans could see them and study them.

Making invisible colors visible

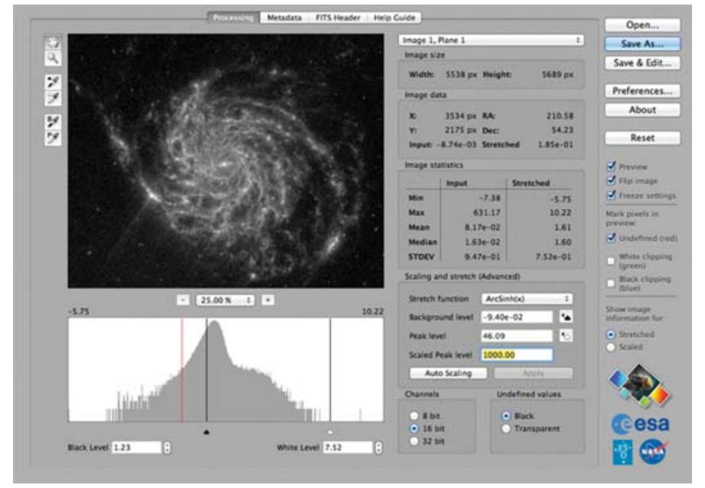
Just as a foreign language can be translated into our native language so that we can understand an otherwise indecipherable message, an image made with light that falls outside the range of our seeing can be "translated" into colors we can see. Scientists process these images so they can not only see them, but they can tease out all sorts of information the light can reveal. For example, wisely done color translation can reveal relative temperatures of stars, dust, and gas in the images, and show fine structural details of galaxies and nebulae.

But the way scientists color these space images is not the same as "colorizing" them or applying "false color." These terms refer to other processes by which color choices are made for artistic or some other non-scientific reasons. The process that scientists use does not "falsify" the image data any more than translating a text from Spanish to English falsifies the meaning.

From extremes to shades of gray

Spitzer's Infrared Array Camera (IRAC) is a four-channel camera, meaning that it has four different detectors, each measuring light at one particular wavelength. Each detector has an array of 256 x 256 pixels. Each image from each detector resembles a grayscale image, because the entire array is responding to only one wavelength of light. However, the relative brightness will vary across the array.

So, starting with one detector array, the first step is to determine what is the brightest thing and the darkest thing in the image. Software called "FITS Liberator" is used to pick out this dynamic range and to re-compute the value of each pixel. In other words, to get a little brighter in the image, a pixel has to get a lot brighter in value. This process produces a nice grey-scale image, rather than an image with a few very white spots and the rest nearly black.



At the end of this process, for Spitzer, we will have four grayscale images, one for each for the four IRAC detectors.

How to turn a gray-scale image into a colored picture

Red, green, and blue are called "primary" colors only because they are the wavelengths of light the human eye happens to be able to see. All the other colors we see are made from various combinations and intensities of red, green, and blue.

The Infrared Array Camera on the Spitzer Space Telescope has detectors for four different "colors" in the

infrared part of the spectrum. Although we can call them colors, they are actually specific wavelengths of light. For Spitzer, the four detectors take images at wavelengths of 3.6 microns (a micron is one-millionth of a meter), 4.5 microns, 5.8 microns and 8 microns, respectively.

Each detector is actually responding to the relative brightness of the light at the particular wavelength to which it is sensitive. So, even if we could see the light the detector sees, we would see only a gray scale image. Not very impressive, so far.

However, for each scene, we will see four grayscale images, each of them different, because each image has recorded a different wavelength of light. Matter of different temperatures emit different wavelengths of light. A cool object emits longer wavelengths (lower energies) of light than a warmer object.

So, are you starting to "get the picture?" Say we turn three of our four (different looking) grayscale images into a different monochromatic color. In other words, let's take the 3.6-micron image and make it blue scale instead of gray scale. And make the 4.5-micron image green scale, and the 8-micron image red scale. If we put them all together, we would have a full-color image.

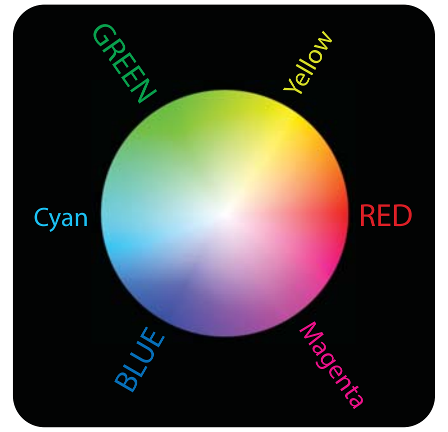
Normally, the three primary colors are assigned to these gray-scale images based on the order they appear in the spectrum, with blue assigned to the shortest wavelength, and red to the longest. In the case of Spitzer, with four wavelengths to represent, a secondary color is chosen, such as yellow. Secondary colors are what you get when you combine two primary colors.

Green + blue = cyan

Green + red = yellow

Blue + red = magenta

So images that combine all four of the IRAC's infrared detectors are remapped into red, yellow, green, and blue wavelengths in the visible part of the spectrum, even though they were originally recorded in the infrared part of the spectrum.



The artful, yet scientific, results

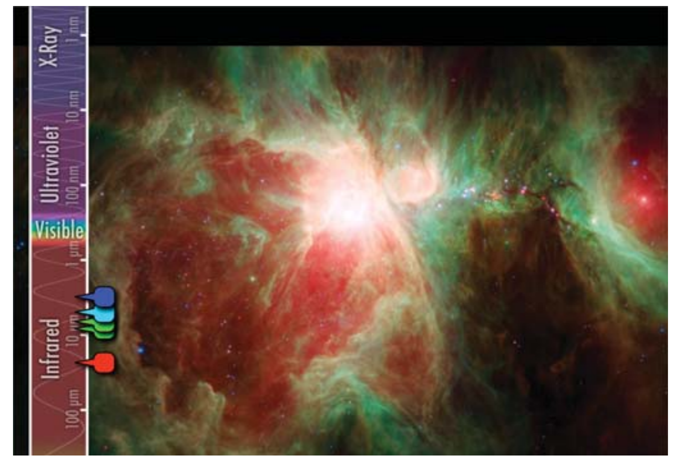
These sample images are equipped with a "color translation" key. A spectrum chart on each image has colored markers that correspond to the colors in the image. The part of the chart where the colored markers are positioned show what wavelengths these colors actually represent in the image.

The higher on the spectrum chart, the shorter the wavelength. So at the top are X-rays, a very energetic form of light. At the bottom of the chart are microwaves, with longer wavelengths than infrared. (These charts do not include gamma rays at the very top, which have the shortest wavelengths, or radio waves at the very bottom, which have the longest wavelengths.)

In this visible light image from the Hubble Space Telescope of spiral galaxy M101, no color translation has been done. So the blue, green, and red markers on the spectrum chart point to exactly the same wavelengths of blue, green and red light that your eyes would see. So, this image appears in its "natural" visible light colors.

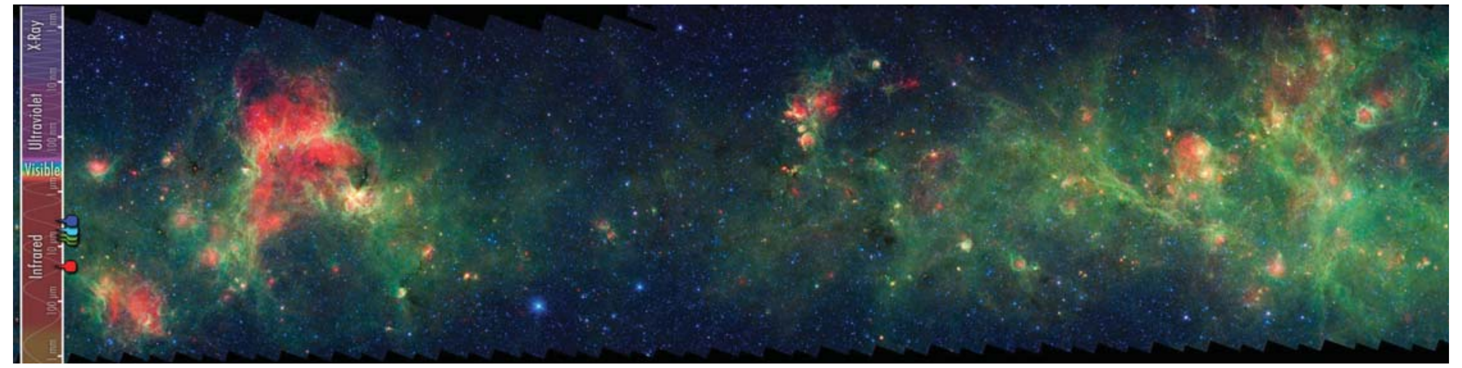
In this Spitzer IRAC image of the same galaxy, M101, red, green, and blue represent wavelengths in the infrared part of the spectrum, so the color markers have been shifted toward longer wavelengths on the spectrum chart. These wavelengths would not be visible to us, so the image coloring process translates them into the "language" of our eyes. This image shows dust that does not show up in the visible-light image, because it is too cool to emit light in the higher-energy visible range.

This image of M101 combines images from four different telescopes, each detecting a different part of the spectrum. Red indicates infrared information from Spitzer's 24-micron detector, and shows the cool dust in the galaxy. Yellow shows the visible starlight from the Hubble telescope. Cyan is ultraviolet light from the Galaxy Evolution Explorer space telescope, which shows the hottest and youngest stars. And magenta is X-ray energy detected by the Chandra X-ray Observatory, indicating incredibly hot activity, like accretion around black holes.



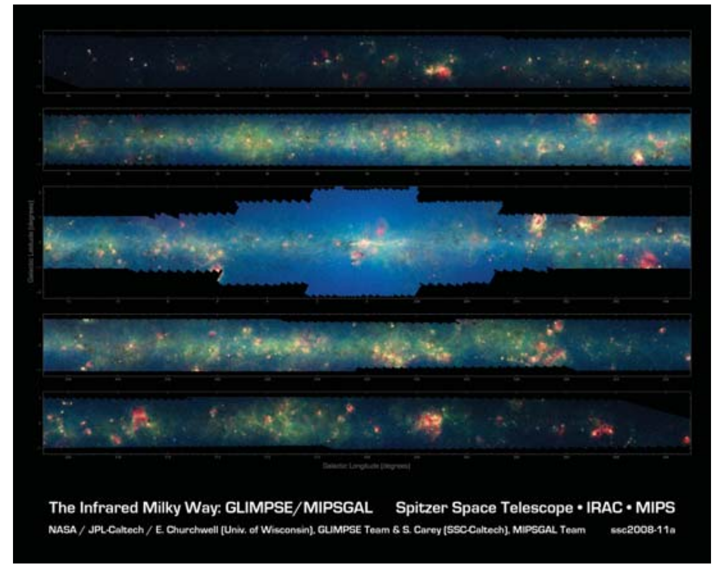
This Spitzer image of the Orion Nebula, near the sword of the constellation Orion, shows an active stellar nursery with thousands of young stars and protostars.

In this image of the Orion Nebula, Hubble data is translated to blues and greens (indicating warm gas), and Spitzer's data is translated to yellows and reds (dust).



The Milky Way image on the front of the poster uses the same color translation as the Spitzer (only) Orion Nebula image above.

Stitching together the Milky Way



More than 800,000 frames from NASA's Spitzer Space Telescope were stitched together to create this infrared portrait of dust and stars radiating in the inner Milky Way. The image on the poster front was taken from the bottom component, which represents the far right side of the galactic plane.

The color translated image is a three-color composite. Blue represents 3.6-micron light and green shows 8-micron light, both from Spitzer's infrared array camera. Red represents 24-micron light detected by Spitzer's multiband imaging photometer. The image also combines observations from the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) and MIPSGAL projects.

Together, these panels represent more than 50 percent of our entire Milky Way galaxy. From Earth, the top two panels are visible to the northern hemisphere, and the bottom two images to the southern hemisphere.

And what do the different colors tell us about our galaxy?

The swaths of green represent organic molecules, called polycyclic aromatic hydrocarbons, which are illuminated by light from nearby star formation. Red shows warm dust. Star-forming regions appear as swirls of red and yellow, where the warm dust overlaps with the glowing organic molecules. The blue specks sprinkled throughout the photograph are Milky Way stars. The bluish-white haze that hovers heavily in the middle panel is starlight from the older stellar population towards the center of the galaxy.

Spitzer Space Telescope

The Spitzer Space Telescope was launched in 2003 to obtain images and spectra by detecting the infrared energy, or heat, radiated by objects in space.

Consisting of an 85-centimeter telescope and three cryogenically-cooled science instruments, Spitzer was at the time the largest infrared telescope ever launched. (The European Space Agency's Herschel Infrared Observatory, launched in 2009, has a larger mirror.) Spitzer has given us a unique view of the Universe and allowed us to peer into regions of space hidden from optical telescopes.

NASA's Jet Propulsion Laboratory in Pasadena, California, manages the Spitzer Space Telescope mission for NASA's Science Mission Directorate, Washington, DC. Science operations are conducted at the Spitzer Science Center at the California Institute of Technology in Pasadena. Caltech manages JPL for NASA.

For more images from the Spitzer Space Telescope, go to www.spitzer.caltech.edu.

Explore more

Galaxy Evolution Explorer:
http://www.galex.caltech.edu
http://www.jpl.nasa.gov/missions/details.cfm?id=5879

Herschel Space Observatory (European Space Agency):
http://www.esa.int/SPECIALS/Herschel

Herschel Space Observatory (NASA):
http://www.herschel.caltech.edu

Online Showcase of Herschel Images:
http://oshi.esa.int/#detail=image.html?id=17

The Space Place (NASA website for kids):
http://spaceplace.nasa.gov/mission/spitzer