3-Color Composite Images – ds9/ImageJ Activity

Purpose: To produce 3-color composite images of supernova remnants (SNRs) from the Chandra X-Ray Observatory data showing areas of low, medium and high energies.

**Introduction and Background – Images and Color**:

The colors we see are the result of how the human eye and brain perceive different wavelengths of light in the visible part of the electromagnetic spectrum – roughly radiation in the range of 380 nm to 740 nm. The ability of the human eye to distinguish colors is based on the varying sensitivity of different cells in the retina to light of different wavelengths. The retina contains three types of color receptor cells, or cones. Light, no matter how complex its composition of wavelengths, is reduced to three color components by the eye. For each location in the visual field, the three types of cones yield three signals based on the extent to which each is stimulated: red, blue and green.True-color images of a subject are images that appear to the human eye exactly like the original subject would: a blue sky is blue, a red apple is red, and green grass is green.


A "false-color" image is an image that depicts a subject in colors that differ from those a faithful full-color photograph would show. The term false-color is typically used to describe images whose colors represent measured intensities outside the visible portion of the electromagnetic spectrum. Astronomical images are false-colored images. A false-color image is not incorrect – it is an arbitrary selection of colors chosen to represent some characteristic in an image, such as intensity, energy or chemical composition. The colors selected are representative of the physical processes underlying the objects in the images, and display in a single image as much information as possible that is available from the data. The data are transported into image analysis software where adjustments are made to emphasize the individual features or processes that scientists are interested in – or enhanced to make the images more interesting to the public.

Although computers and software are used extensively, scientists and programmers go through painstaking calibration and validation processes to ensure that technically correct images are produced. The colors used for the images are selected to emphasize specific information within the data. The color selections used by the Chandra X-ray images are usually associated with intensity or brightness, or energy. For example, in the yellow and orange Chandra X-ray image of the Cas A supernova remnant to the right, the white and yellow colors represent the areas of highest X-ray intensity, the orange to red areas represent the areas of lower intensity, and the black represents little or no emission.

Cas A SNR (Chandra)

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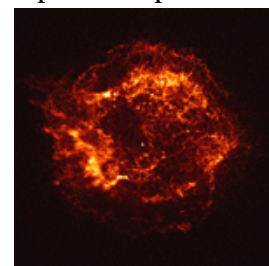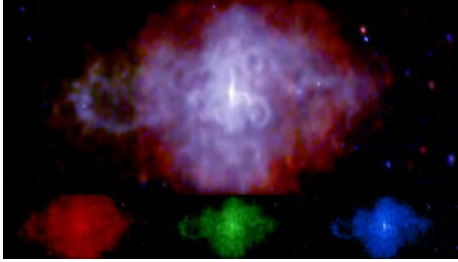
3C58 (Chandra)

The X-ray image of the pulsar 3C58 on the left shows an image constructed by selecting different X-ray energy bands from the data and representing them with different colors – red, green, and blue. The result is a 3-color composite image. The low, medium, and higher X-ray energy bands of the Chandra data are shown as red, green, and blue respectively. In this particular image, red, green and blue represent X-ray energy bands of 0.5 to 1.0 kilovolts, 1.00 to 1.5 kilovolts, and 1.5 to 10 kilovolts, respectively.
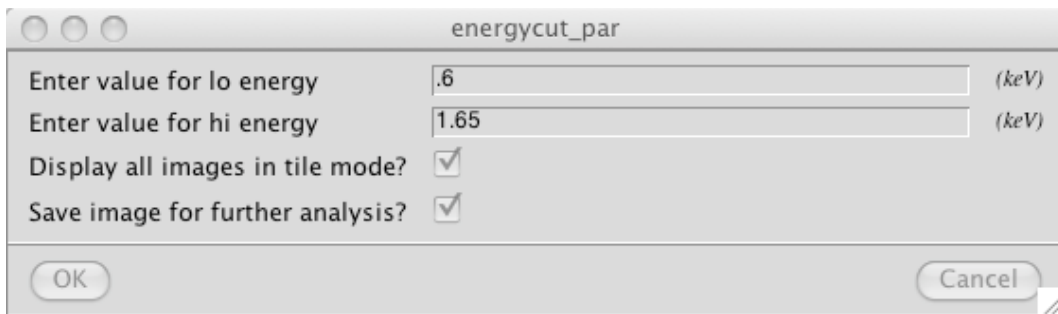
In this activity, two image analysis software programs, ds9 and ImageJ, are used to construct a 3-color composite image of the Cas A supernova remnant. The red, green, and blue regions in the composite will show the intensities of low, medium, and high-energy X-rays – as in the composite image of 3C58 above. The ds9 software utilizes data sets and astrophysical analysis tools from the Chandra X-Ray Observatory. The program uses the same process that X-ray astronomers follow in analyzing the data from Chandra observations.

The download and installation instructions for the ds9 toolbox are located at http://chandra-ed.cfa.harvard.edu/install_2014.html. The introduction http://chandra-ed.harvard.edu/learning_ds9overview.html describes the overview and purpose of the software and gives a short summary of the Chandra mission. The tutorial for using the ds9 software is located at http://chandra-ed.harvard.edu/learning_ds9.html. ImageJ is a software program developed by the National Institutes of Health and is available free for download from http://rsbweb.nih.gov/ij/download.html.
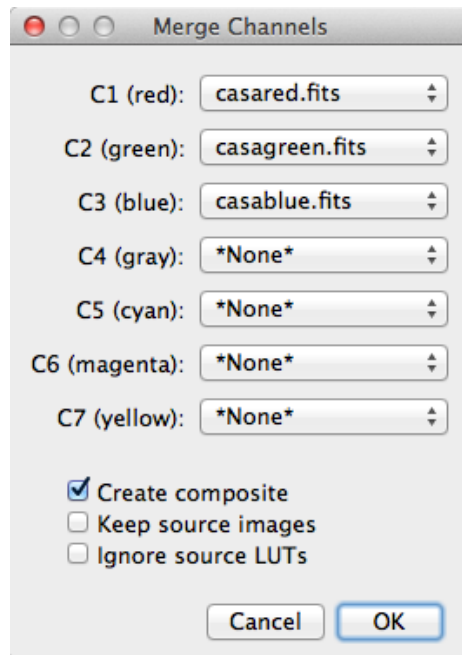
NOTE: It is not necessary to read the tutorial before beginning the 3-Color Composite Images – ds9 Activity. Complete instructions to use the image analysis tools in ds9 are given in the following procedure.

Procedure:

1. Download and install ds9 (http://chandra-ed.cfa.harvard.edu/install_2014.html)

2. Open ds9 and maximize the screen. From the pull down menus, choose **Analysis>Virtual Observatories** and choose Chandra-Ed Archive Server or New Rutgers X-Ray Analysis Server from the list that appears.

3. Click **Obs ID 114 ACIS OBSERVATION OF CAS A (first 5K seconds only)** in the new window that appears.

4. Use **Analysis>Chandra Ed Analysis Tools>Energy Cut** to show only the X-rays in the soft band (lo = 0.6 KeV, hi =1.65 KeV). Leave "Display all images in tile mode?" and "Save image for further analysis?" checked.

energycut_par

Enter value for lo energy .6 (keV)
Enter value for hi energy 1.65 (keV)
Display all images in tile mode? ✓
Save image for further analysis? ✓

OK Cancel

5. The image will come up in a new frame on the right (if the right frame is not outlined in blue, click it).Saving the file on a PC: go to **File**>**Save Frame as FITS**. Name this file *casared.fits*. Saving the file on a Mac: go to **File>Save**. Under **Selection** in the new window that comes up, change the name of the file from /Users/username/ds9.fits to /Users/username/casared.fits. For both PC and Mac, choose **Frame**>**Delete Frame** to leave only your original image.

6. Repeat steps #4-5 for the medium (1.65-2.25 KeV) and the hard (2.25-7.50 KeV) bands, saving them as *casagreen.fits* and *casablue.fits*, respectively.

7. Download and install ImageJ and run the program.

8. Go to **File>Open** three times to load casared.fits, casagreen.fits and casablue.fits.

9. Go to **Image>Color> Merge Channels**. From the pull-down menus in the new window, choose the appropriate files to go with each color as shown below and click **OK**.

Merge Channels

C1 (red): casared.fits
C2 (green): casagreen.fits
C3 (blue): casablue.fits
C4 (gray): *None*
C5 (cyan): *None*
C6 (magenta): *None*
C7 (yellow): *None*

☑ Create composite
☐ Keep source images
☐ Ignore source LUTs

Cancel OK

10. A three-color composite of Cas A has now been created. Use the following tools to enhance the image to emphasize different features.

- Image>Adjust>Size
- Image>Adjust>Brightness/Contrast
- Image>Adjust/Brightness/Color Balance
- Process>Smooth
- Process>Sharpen

Extension:

Use the same method to produce 3-color composite images for the following two objects:

1. Obs ID 7639 - A Deep Chandra Observation of the Tycho Supernova Remnant
2. Obs ID 115 - ACIS Observation of Tycho and Kepler

If the Obs ID for the supernova remnant (SNR) is not in list in the internal browser window, scroll to the middle of the page under **Search the Chandra Public Archive for Other Observations** and click on **Unofficial Chandra Public Archive**. Enter the Obs ID and click "Search" – then click on the **Title** of a returned observation to load it into ds9.