

openFITS

unlocking the mysteries of astronomical image processing

With a basic understanding of astronomical data and image processing software, you can create your own astronomy images from FITS files. "FITS," which stands for Flexible Image Transport System, is a digital file format used mainly by astronomers. Check out chandra.si.edu to download FITS files for some of our favorite Chandra images and learn how to compose your own versions of these high-energy astronomy images.

Data available at:

<http://chandra.si.edu/photo/openFITS>

Example data:

<http://chandra.si.edu/photo/openFITS/crab.html>

Software - GIMP v2.8

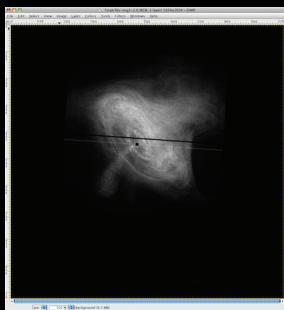
<http://www.gimp.org>

**START HERE TO
MAKE YOUR OWN CRAB**

1

OPEN & CHANGE MODE

Open your FITS file in GIMP using **File>Open**. GIMP has a built in FITS reader and you should be able to use the default settings.



The image opens in grayscale and you use **Image>Mode>RGB** to switch to RGB mode so we can add color down the line.

2

ADJUST LEVELS

Your first view of the image was very dark. Even though GIMP automatically rescaled the FITS data, the image still needs to have its pixel levels adjusted.

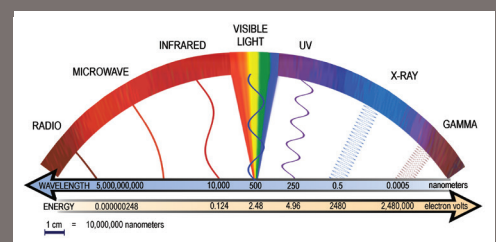
Open the Levels dialog box by selecting **Colors>Levels** and feel free to adjust the small triangles under the histogram plot in "Input Levels" to your liking.

The trick with adjusting the levels at this stage is to bring out faint details in the object but minimize the amount of background "noise" in the image. Play around with the sliders and see how subtle changes in the levels affect the image.

COLOR IN ASTRONOMY

The colors we see with our eyes everyday are the result of how the human eye and brain perceive different wavelengths of light in the visible part of the electromagnetic (EM) spectrum. 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 EM spectrum extends beyond visible light in both longer and shorter wavelengths which are

not perceived by the human eye. X-ray light is light at a much higher energy than the eye can perceive, while Infrared light has a longer wavelength than visible light. Much of what we see in astronomical imagery has been "translated" into light that we can see with our eyes. Typically referred to as "false color" the data in astronomical imagery are color coded to render them in colors we can see.



3

SMOOTHING

Your image may display some pixelation artifacts that could benefit from a light touch of smoothing. You can try out GIMP's built-in Gaussian smoothing in **Filters>Blur>Gaussian Blur**. For the Crab Nebula, a light Gaussian blur with a radius of 2 pixels should give good results.

4

IMAGE ARTIFACT REMOVAL



You may have noticed some odd looking image artifacts like the dark line running through the nebula, and the black spot with light lines stretching out from either side. These are not actually part of the source, they are instrumental artifacts that will need to be carefully removed without introducing new artifacts.



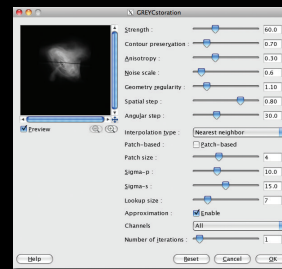
We know that the central black dot is actually the source of the most intense X-rays in the image; so intense that the detector was not able to accurately record the light coming from that region and instead was saturated to the point that there is no useful data, hence the "black hole." We can simply, but carefully, replace the black in this region with white, to indicate the most intense light in the image.



The light lines extending from this central region are "readout streaks" created by residual X-ray photons streaking across the detector as the image is transferred from the CCD. You would see similar artifacts on your own digital cameras, or cell phone cameras when they are exposed to bright pinpoint sources of light, like the sun (do not stare directly at the sun). These lines can be removed by using GIMP's handy **Healing Tool** which is designed to repair image irregularities. To use it, select it in the **Toolbox** and then **CTRL-click** a region of the image near the artifact to define the source pixels, then click on the artifact itself and drag across.



5



A SPLASH OF COLOR

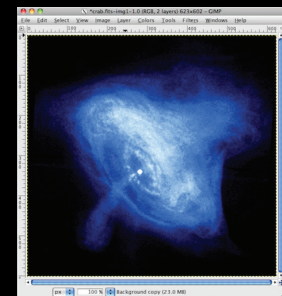
As a broadband image, you would typically apply a single gradient map of color to the image to show

X-ray intensity. To apply color to your layer, go to **Colors>Colorize**. Sweeping the **Hue** bar left to right will cycle through the spectrum of colors available to you. Choose what you like and hit **OK**.

6

FINISHING TOUCHES

Your image is essentially done at this point and any further adjustments are a matter of personal taste. For example, you may want to do one last levels adjustment to enhance image contrast. You can do this via GIMP's Curves adjustment in **Colors>Curves**. Further tweaks to the image color can be made using **Colors>Color Balance** to suit your taste.



MOST IMPORTANTLY, HAVE FUN TURNING RAW DATA INTO YOUR VERY OWN ASTROPHOTOGRAPHY!