Image Analysis at the Peter van de Kamp Observatory
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It is assumed that you have a reduced set of data (images in the pipelineout folder) produced by running the image reduction procedures in Alj, as described in the accompanying document. In this document, we'll use a set of B, V, and R images of the Crab Nebula (M1) to demonstrate the procedure for processing images in order to make a single, color composite image.

A few notes about the images

The format of the images taken with the camera on the Peter van de Kamp telescope is called FITS (Flexible Image Transport System) – the usual format of astronomical images but one that’s not common outside of astronomy. FITS images can’t be read by web browsers or most image viewing and manipulation programs. But of course they can be read by Alj.

A standard set of images uses the B, V, and R filters – top row of transmission curves:
You will generally want to inspect the reduced images from each filter set before you start the image processing and throw out any that are blurry or otherwise less good quality than the best among the set you have. You may already have done this before the reduction steps.

**Looking at the images:** Open images by choosing *File > Import > Image Sequence*

and navigating to the `pipelineout` folder; click the *Choose* button and you should see this interface:

It’s important to check the “Use Virtual Stack” option if it isn’t already. Note that 18 files and folders are found (2048 X 2048 X 18, near the bottom; that’s what the 18 refers to, while the 2048 X 2048 refers to the dimension of each image, in pixels). If
you enter "B" in the “File name contains:" window then *AIJ* will see just the five files in that folder with the letter B in their names (and so, just the five images taken with the B filter):

![Sequence Options](image)

You should do this and then click on the OK button and an interface opens up showing the stack of five images.

**Pixel count levels in a region**

You can measure how the count level in each pixel varies across a region of the image. To do this, choose the line tool:

![AstroImageJ](image)

Make a line across an image, and choose analyze > plot dynamic line/box profile:
The graph shows the number of counts in each pixel along that yellow line. You can draw the line elsewhere on the image and the graph should automatically update.

**Producing the color composite**

Now that you have examined your images and learned how to find out the relative brightness in different parts of an image, here are the steps you will go through to produce your color composite image:

1. For each group of images taken with a given filter, align the images.
2. Add the aligned images together to produce one “master” B image, one master V image and one master R image. By adding together separate five-minute exposures, we'll effectively have images that represent longer exposures.
3. Align the three master images.
4. Colorize each of these three master images.
5. Combine the color images together, adjusting the intensity of each one.

You'll see below that steps 4 and 5 are essentially done at the same time.
Aligning the images for each color: Start with the B images. The images of the Crab Nebula in this example are already well aligned. This step will probably only make very small changes to their positions. But for other datasets, alignment might be absolutely necessary if the telescope pointing was not perfect from image to image. If we don’t align the images, then when we combine them together in the next step, the resulting image will be blurry.

With the stack of B images open, click on the alignment icon (indicated by the arrow in the next image).

When you click on the alignment icon a new window will open up:
These settings are good – you should use the same ones (adjusting “Last slice” based on the number of individual images you have in your stack).

Click “OK” and you’ll be shown the first image in the stack and the cursor will again be a target-like icon of concentric circles. Center it on any bright star in the image and click – the target will turn red and be centered on the star you chose. Repeat the process for about ten bright stars distributed around the image. You should see something like this:
Once you’ve chosen about ten stars, you can press the enter key (or right click anywhere on the image) and the stack of five images will be aligned (each image shifted so that all the stars you chose are in the same place in each image) and those aligned images will be saved into a (new, automatically created) folder called `aligned`.

Check to make sure that the aligned images are actually there! They’ll have new names that start with `aligned_`.

**Combining the aligned images taken with the B filter:** The next step is to create the master image for the B filter that will be a single image combining the five individual images taken with the B filter. So, first, import a stack of the aligned B images (make sure you import them out of the `aligned` folder). You can step through the aligned B images you’ve just opened up in a stack to make sure they really do
look aligned. Then you can make the master image using the Process menu: **Process > Combine stack slices into a single image.** You’ll see a small dialog window confirming that you’re combining five images (“slices”). You can choose the “average intensity” option and click “OK.”

Once you click “OK” a new window will open up with that new, single, averaged image in it:
Note that this is now a single image, representing the average (on a pixel-by-pixel basis) of the five aligned images. This new master image is not yet saved – you have to save it using File > Save image/slice as FITS and give it a sensible name (like M1_B_master.fits) and save it in a reasonable place – like the aligned folder. Check to make sure it’s there!

This combined image should be less noisy and the image sharper (though this may not be very obvious – but see the counts per pixel across another line in more-or-less the same place we put the line in the raw image).
Repeat this opening, aligning, and combining procedure for the V and then the R images.

Once you’ve done this, you should have three master images – one for each filter. The next step is to align these three images with each other. Follow the procedure you used for the stack of individual images for the B filter (import a stack containing the three master images, do the alignment). You should end up with a new folder (also) called `aligned` in the folder where the three master images are (so a second folder called `aligned` in the first folder called `aligned`), and in that folder you'll find three new files that will have `aligned_` pre-pended to the file names of the master images.

Open these three files in an image stack. Step through them and look carefully at them.
**Colorizing and combining:** In the window showing your stack of three images, use the menu option *Color → Make Composite color image*. A box will come up; use the drop-down to change it so that it says “Display Mode: Color.” Then another box will come up, with the title “Channels” and the check box for Channel 1 selected.

![Channels window](image)

A color will have been chosen for the first image (channel 1), and you can change that color using the “More” button. Cycle through the channels, choosing an appropriate color for each channel (recall the colors of the B, V, and R filters).

Here’s the aligned master B image in blue:
Note that the B image was the first one in the stack by virtue of alphabetical order and it was red when I initially opened up the color compositor. If you've set all three images' colors correctly, you should be able to use the slider below the image (see the red arrow) to step through each image and they'll have appropriate colors.

To combine the three colorized images, change the small menu from color to composite.

Here is what you might see when you do that:

This looks pretty good!
But you might want to adjust individually the contribution of each of the three colors.

Go to the Scale menu and set it to fixed brightness & contrast (per image slice).

Each of the three slider positions will show you the composite (combined) image, but you can control the grayscale level of each individual color image by setting the slider to the appropriate single-color image (here it’s the green-coded V image – see the green text near the top of the above image) and then adjusting the two small pentagonal sliders above and below the gray histogram.

Try different grayscale setting for the colors. There’s some subjectivity involved in your choices. But some guidelines to generating a realistic and attractive image include aiming for a black, uniform sky and trying to make stars look relatively white.
When you have a composite image that you like, save it (File > Save image display as png) with a distinctive name (perhaps containing composite or final).

Note that you can zoom in and pan around. Save any additional versions of the image that you create.

Your own image will look somewhat different, due to your color and grayscale level choices.

Once you can see the dominant colors in different parts of the nebula, you can go back to the individual color master images and see if, for example, the reddish parts of the nebula look extra-bright in the pure red image.