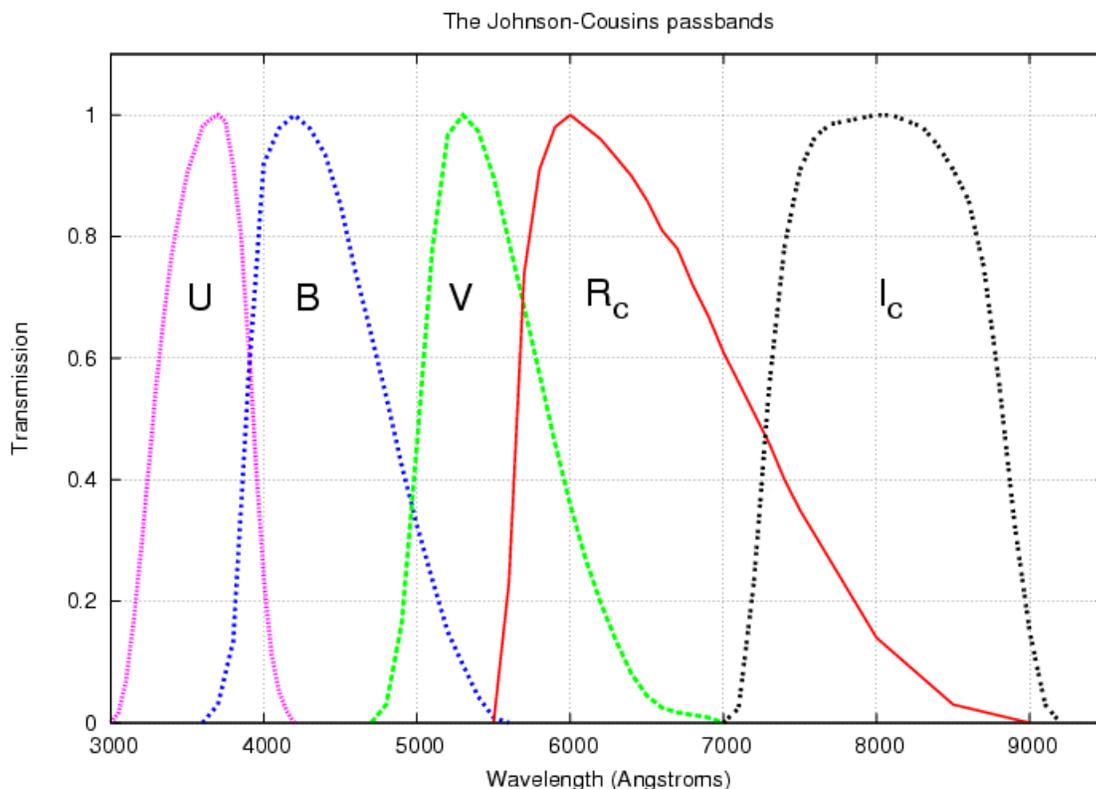


Color Images (version 7)

We've been working with images in "white" light. Mt. Cuba's CCD camera, and most professional astronomical cameras, do not record images in color. It is possible using such cameras to create color images. The process is a bit more complicated than just white light, where shades or gray are determined simply from the number of photons counted on each pixel. Color images require separate images of your object in at least three filters (green, red, and blue). An image taken with no filter (usually includes "nf" in the file name) helps improve the detail in the final image. At Mt. Cuba, we use the Johnson filter system, so our typical filters are u (ultraviolet), v (visual), b (blue) and r (red). The U filter only allows ultraviolet light (around 3500 Angstroms) through, the B (blue) filter lets light around 4500 Angstroms through, the V (visible, also called green)



filter lets light around 5500 Angstroms through, and the R (red) filter lets light around 6500 Angstroms through.

At MCAO, image file names will contain the appropriate filter letter (b,v,r,nf) in their name. Calibrated color images also require separate flat fields taken in each filter. The three (or 4 if using the nf option) different images (are calibrated separately, using the corresponding flat taken with the same filter. The final step is to combine the 3 (or 4) images to create a final color image. The steps below outline the reduction process. This information is also covered in the book (Ch 21). Make sure you read the relevant pages before attempting this exercise.

1. **Calibrate the images for each color.** Choose an object for which we have color observations (for example: Orion Nebula, M31, M13, or M57). You must calibrate the images for each color separately. The main change is in the flat fields. The calibration setup window must be updated for each color by loading the appropriate flat field for each image. You do not have to reload the biases and the darks. After you have loaded the appropriate calibration files in the calibration setup window (see Image Analysis for the process), click “Multi-Image→ Autoprocess→ Deep Sky and select the images that match the flat field you are currently using. Repeat for each color. You will end up with a averaged stacked blue image (using images taken with the b filter), an average stacked green image (using images taken with the v filter), an averaged stacked red image (using images taken with the r filter), and a stacked clear image (using images taken with nf (no filter). Save each of these stacked images or keep them available on your desktop.
2. Open your stacked images, if they are not already open.
 1. Include screen shots of your averaged stacked images in your report.
3. Use the gradient correcting and sky background corrector tools on each of your stacked images, if necessary.
4. **Register the Images.** You need to align the separate images so they can be combined properly. Click on Multi-Image→ Register Images. The Image Registration Tool will appear. Register the red, green, and blue images using the nf image as your reference image (master). Select “ 2 star alignment”. Once you have specified your reference and slave images, click “Register Images”. The program will take you to the reference image, with the heading “Select Alignment Stars”. Click on the first star you wish to use. Go back to the Register Images Tool and click Star 1. Repeat for star 2 . Click “Ok”. The program will then ask you to select the same alignment stars in each image. When you have finished, the program will shift each image a bit to place the alignment star in the same spot in each image.
5. Click on the Colors→**Join Colors Tool**. The menu item will open (move it to the edge of the screen so it will not obstruct your view of the image). You will see a set of four drop-down list boxes labeled Red, Green, Blue, and Luminance. Select the appropriate box for the appropriate image. Select your stacked Red image for “Red”, your green image for “Green”, your blue image for “Blue” and the clear (no filter) image for Luminance
6. **Create a color Image.** AIP4WIN will automatically balance your color images.
 1. Select “Automatic Color” as your color option.
 2. Change the output range to 65535.
 3. Clicking the “Make Color Image” button. A color image is created.
 4. Describe how your image looks. Is it dark? Do the colors look realistic?
 5. Include a screenshot of your color image in your report.
 6. It might also be helpful to save your color image.
7. Now it is time to play a little. Go back to the Join Colors Tool. We will explore some of the neat things you can do when creating your color images. If necessary, start by selecting your red, green, blue, and luminance images.
 1. **Adjusting the Brightness.** This is useful if your image is too dark.
 1. Select the “Automatic” tab in the Join Colors Tool and set the Image Brightness control to 0.992 and the Histogram HiPoint to 0.998, and click

- the Refresh Current Color Image button. The resulting image should look brighter. What happens in your image?
2. Select the **Adjuster** tab and slide the Gamma slider to a value of 1.7 and click the Refresh Current Color Image button. Faint detail should be more prominent. What happens in your image?
 3. Experiment on your own, and record the effects you see for different settings, and record the values you find for your image.
 1. How does changing the Image Brightness affect color balance? Look in your textbook for an explanation.
 2. How does the Histogram HiPoint affect the color balance? Look in your textbook for an explanation.
 3. Include at least one screen shot of an interesting image you create.
8. **Cleaning Up Color Artifacts.** AIP4WIN provides useful tools for controlling artifacts due to such things as chromatic aberration and saturation. Open the Color Effects Tool (you must have created a color image to be able to open the tool).
1. Click the **“Cut-Off/Roll-Off”** tab.
 1. Return to your original color image.
 2. This tab deals with the effects of saturation
 3. The default values for the low and high cut offs are based on 24 bit color. We need to change to 48 bit color.
 1. Change the Low Cut/Roll to Low = 0 and Low Rolloff = 10000
 2. Change The High Cut/Roll to High Roll = 55000 and High Cut = 62000.
 3. Click **“Apply Color Effect”**
 4. Include a screen shot of your new image.
 4. What changes in the image?
 5. What is chromatic aberration?
 6. What meant by saturation in this instance?
 7. How do the Rolloffs and Cutoffs affect the color balance? Look in your textbook for an explanation.
 8. Experiment with the input values. Can you make the saturated stars look **“unsaturated”**?
 2. Click on the **“Saturation”** tab.
 1. Return to your original color image.
 2. Slide the bar towards Less Saturation and Apply the Color effect.
 3. What happens to the colors in your image?
 4. Slide the bar towards More Saturation and apply the color effect.
 5. What happens to the colors in your image?
 6. What do you think the term **“saturation”** means in this instance
 3. Click on the **“Chrominance”** tab.
 1. Return to your original color image.
 2. The color image contains two components. The first is the **“Luminance”** component. Luminance is the brightness component. The second is the **“chrominance”** component. Chrominance is the color component of an image, characterized by its hue and saturation.
 3. The chrominance tab lets us explore the color component of an image by setting the luminance to a constant value over the entire image.

- Experiment by setting the desired luminance to 20000. Click “apply color effect”
4. Describe what happens to your image.
 5. Repeat for luminance values of 0 and 60000.
 6. Include screen shots of your image at 20000.
4. Click on the “**Smoothing**” tab
 1. Return to your original image
 2. Smoothing softens color transitions and can help with color noise.
 3. Slide the bar towards less color smoothing.
 1. Click on Apply Color Effect.
 2. What happens to your image?
 4. Slide the bar towards more color smoothing
 1. Click on Apply Color Effect
 2. What happens to your image?
 5. Find a “smoothing” value that improves your original image. Include a screen shot of that image.
9. **Crop the Image.** Often there is an area around the edge of the image where the individual color images did not overlap when they were registered. You can crop the edges off by clicking Transform→ Crop. The Crop Tool window will appear. Use the mouse to select the region you wish to keep and click the Apply button. A new image will be created from the selected region.
10. **G2V color:** To make accurate color images, the signal in each separate image must be proportional only to the flux from the celestial object in each filter (also called bandpass). A reliable way to do this is to obtain filter images of a standard object of known color. In astronomical imaging, we use main sequence stars like our sun (classified as spectral type G2V) as standards.
 1. Return to the Join Colors Tool.
 2. Change the Join Colors Method to G2V.
 3. Create a new working image.
 4. How does this image differ from the one created with the “Automatic Color” method?
 5. Include a screen shot of this color image in your report.
 6. Experiment with the G2V color option (in the Join Colors Tool).
11. **Saving the image.** When you are satisfied with your results, the color image you created can be saved in many different formats.
 1. Click File→ Export, and a box will appear to prompt you for the file name and location. You can select the format you want to save your file in. AIP4Win does not save a color image in FITS format.
 2. Many programs do not recognize FITS format, so JPG or TIF are popular.
 3. If you want to preserve the greatest flexibility for future editing of your image, you should save it as a 64-bit floating point FITS file. This format preserves the full dynamic range of your data along with all the color detail.
 4. **Include your final image in your report.**
12. Stars vary their light output at different wavelengths. Reload your stacked images for each color. Start with the clear image. Select 10 stars from the image. Don’t chose just the bright stars. Mix in some fainter ones. Click Measure→Photometry→ Single Star. The single star photometry tool will appear. Click on your first star. Information about your star will appear in the

Tool box. Record the x and y coordinates, and the Star-Sky value (in ADUs). Repeat for your other nine stars, and then repeat for each image. You should end up with a table something like the following:

Star	X coord	Y coord	Blue	Green	Red	Clear	
1	145	150	30000	40000	60000	100000	
2	300	200	10000	30000	20000	30000	
3	550	400	5000	2000	1000	3000	

- 5) Create a graph using (Blue-Green) for the x axis, and (Green-Red) for the Y axis. What do you find? Consult with other members of the class and create a graph using everybody's stars.