Digitally Removing Uneven Field Illumination

A problem that is encountered with many telescopes, and nearly all camera lenses used for long-exposure deepsky astrophotography is uneven field illumination.

It can be caused by vignetting, or by the geometrical properties of the optical system, especially in fast lenses. It can also cause color shifts, probably due to reciprocity effects.

After enhancing the contrast to reveal faint details in the image, this uneven field illumination will be exaggerated and objectionable.

Contrast stretched image clearly showing uneven illumination and color differences between the center of the field and the corners.

Several methods of digitally removing this type of defect have been described previously. The first that I am aware of was by Richard Berry in an article entitled ***Working in the Digital Darkroom*** in the August 1994 issue of Astronomy Magazine. An article by James Foster based on this technique is available on his web site.

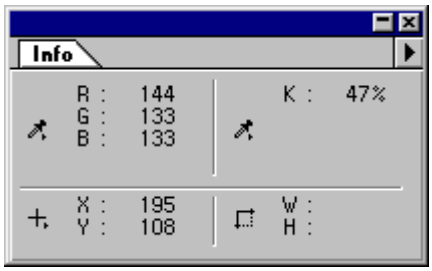
Basically, Berry's technique applies a series of blurring filters to the original image which removes the stars and leaves just the uneven field illumination. Then this mask is subtracted from the original image. A drawback to this technique is that it can be difficult to remove bright uneven nebulosity in the field. An advantage of the technique though is that it can remove irregular uneven illumination, such as caused by the shadow of an off-axis guider pickoff prism or mirror.

The technique described here uses another method in Photoshop that uses layers and can correct both the uneven illumination and color .

It is recommended that you work on low resolution image files of approximately one megabyte for learning this technique as it can be quite processor intensive and slow on large high resolution images.

Density Correction

By using the INFO palette in Photoshop with the second readout set to grayscale, we can read both the color balance and the density of parts of the image.



The Info Palette

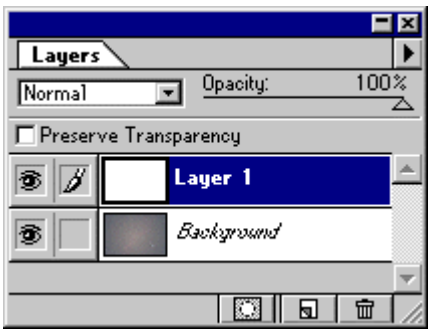
Reading a portion of the negative near the center, being careful with this particular example not to select a part of the frame that has any nebulosity, we can see that the densitometer in the INFO palette reads approximately 144-133-133 for R-G-B values, and 47 percent for the density. The upper left corner reads approximately 97-102-113 and 60 percent.

Original un-enhanced scan

Arrows indicate where the density and color were read with the info densitometer.

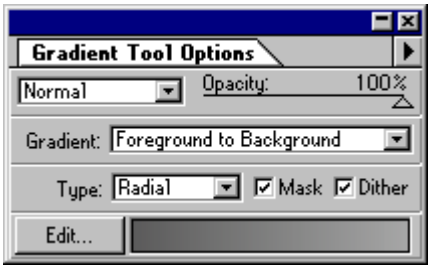
This tells us that the center of the image is a little bit red and the corner is blue. The difference in density is about 13 percent.

First we will create a new layer on the original un-enhanced scan. Open the **Layers** palette and clicking on the small triangle in the upper right corner, select **New Layer** and ok it. The new layer will now be highlighted in the **Layers** palette indicating that it is active.



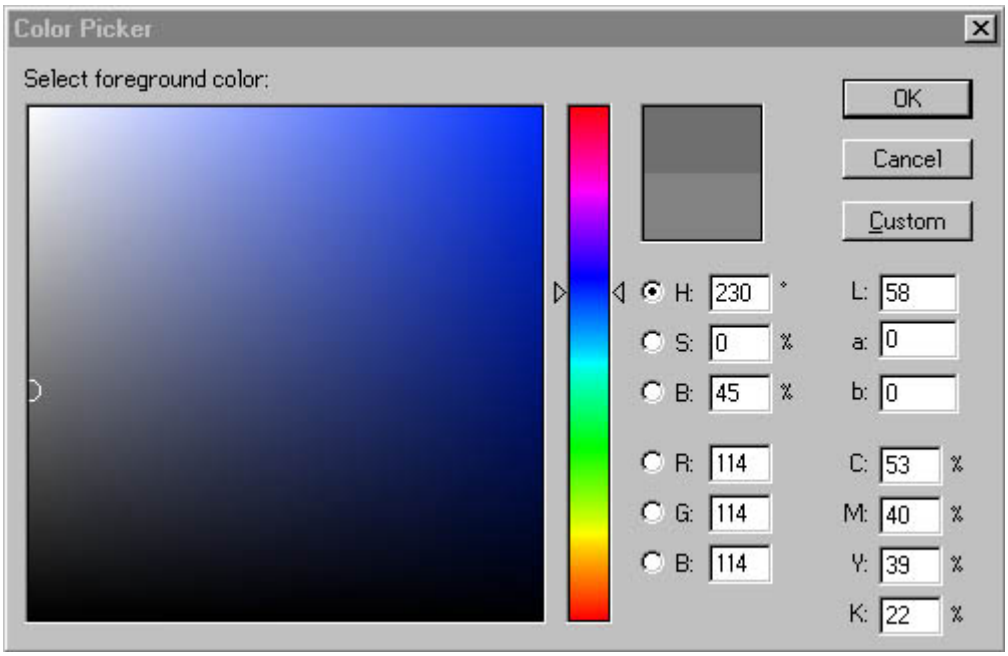
Layers Dialog

Select the gradient tool in the tool palette and double click on it to bring up the gradient tool options box. Change the tool type to circular from linear. Leave the blending method set to normal, the opacity to 100 percent, the style from foreground to background, the midpoint at 50 percent, the radial offset to 0, and check the dither box on.



Gradient Tool

Double click on the foreground color in the tools palette and bring up the color picker dialog box. By moving the circular selection indicator in the color window you can pick a foreground color . Drag the circle to the left side of the image approximately a little below the center of the left side. This will place a shade of gray slightly darker than middle gray into the foreground color box. Take a look at the numbers at the right and you will see the R-G-B values. 128-128-128 is middle gray. 0-0-0 is black and 256-256-256 is white. Try a set around 114-114-114 for the foreground color .



Color Picker

Double click on the background color and try 152-152-152.

These numbers will vary depending on the amount of uneven illumination that is present in the original and the contrast at which you scan it. Try experimenting.

Activate the gradient tool now by clicking on it. Make sure the layer is active by clicking on it in the LAYERS palette. Place the cursor in the middle of the frame and click and drag the cursor to the top left corner. You will see a line form as you drag the cursor indicating the starting point and ending point where you let go. This is where the gradient will be created from the foreground color in the center of the image to the background color in the corner. The gradient will be created as soon as you release the mouse button after dragging to the corner.

Radially graded density correction layer

You have now created a radially graded fill on the top layer. You can't see the original image any more because the layer is on top of it with a 100 percent opacity. The original is still there though. Just click on the little eye next to layer 1 in **Layer** palette and turn the eye off, and the layer will be hidden and you can see the original image again.

Here comes the trick part. Now change the type of blending in the **Layers** palette to **Hard Light**, and click the eye back on so you can see the effect on the original image.

You should see the center of the original image darken as the corners lighten as the radially graded fill is applied. Click the eye next to layer 1 on and off to see the effect toggle.

Original Image with uneven illumination corrected by blending a radially graded density mask

Read the same sections of the image with the densitometer and you should see that the density now reads approximately 49 percent in both the center and the upper left corner. You have successfully removed the uneven field illumination.

However, the uneven color still remains as seen in the R-G-B values in the info palette. This is subtle here, but if we were to contrast stretch the image now, this problem would become even more noticeable.

In the **Layers** palette, click on the little triangle again and now select **Flatten Image**. This will permanently apply the radially graded blend that corrected the uneven illumination.

Color Correction

You can now proceed to correct the uneven color using the same radially graded layer method. Only now you will keep the foreground and background colors the same density and only change their color .

This is accomplished by keeping two of the numbers in the foreground and background color picker dialog at 128. In the astrophoto example here, the center of the image is slightly red compared to a neutral gray, and the corner is blue. By blending a radially graded fill with the complementary colors we can remove these color shifts.

Radially graded color correction layer

We will blend some cyan into the middle and some yellow into the corners. Create a new layer again, but this time select **Softlight** as the blending method.

Click on the foreground color , and in the color picker keep the R-G-B values of the other two colors that you don't want to change at 128 and change only one color . Try 112-128-128 (slightly Cyan) at the center, and 128-128-104 (slightly yellow) at the edge.

Click the gradient tool and drag from the center to the corner on the layer. Check the resulting corrections in the info box with the densitometer and if they are correct, flatten the image.

Density and Color Corrected Image

There is only one problem now, the background sky color should not be a middle gray!

From this point I continue with my normal digital enhancement techniques, setting the sky background to an aesthetically pleasing dark blue with R-G-B values of about 15-25-45.

Density and color corrected image

Sky background black point set to 15-25-45

The only thing left to do is to increase, or stretch the contrast. By dragging the black point and white point sliders towards the middle in the Levels dialog box, you set a new black and white point, increasing the contrast.

Final Image

Uneven illumination and color corrected,

Sky background black point set,

Contrast Stretched

Note that both the color correction and density correction can be combined in one layer operation, in this example, the radially graded layer would be darker and cyan-color ed in the center, changing to lighter and yellow-color ed in the corners.

Remember to blend via **Hardlight** or **Softlight** with a layer that is the complimentary opposite of what you want to correct in the original. For example, if the original's center is light and red, make the blending mask dark and cyan in the center.

The gradient tool in the linear mode can also be used to correct for different types of uneven illumination, such as objects in the sky that are photographed at relatively low elevations in areas where light pollution is present. In some wide angle images, such light pollution can be bright and cause incorrect color at one corner or edge and fade to the normal sky color at the opposite side of the image.

Enhanced 4 Exposure Composite

Composite of 4 exposures

To increase the signal to noise ratio of the extremely faint nebulosity in the image, multiple originals can be combined. The final image presented here is a composite of four original exposures. For a larger version of this image and details on the exposures see this photo of Barnard's Loop.