# Post-Processing in Nebulosity

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Step 0

Load the stacked image if you're not just coming out of Align and Combine. We'll zoom out with the **–** (minus) button to let us see the whole frame. The data here come from a shot of M27 taken on a SBIG ST2000 XCM with a TMB-80SS and a Baader UHC filter. 10 shots were stacked (5 min each, guided in PHD Guiding using an 8x50 finderscope under a full moon in urban skies).
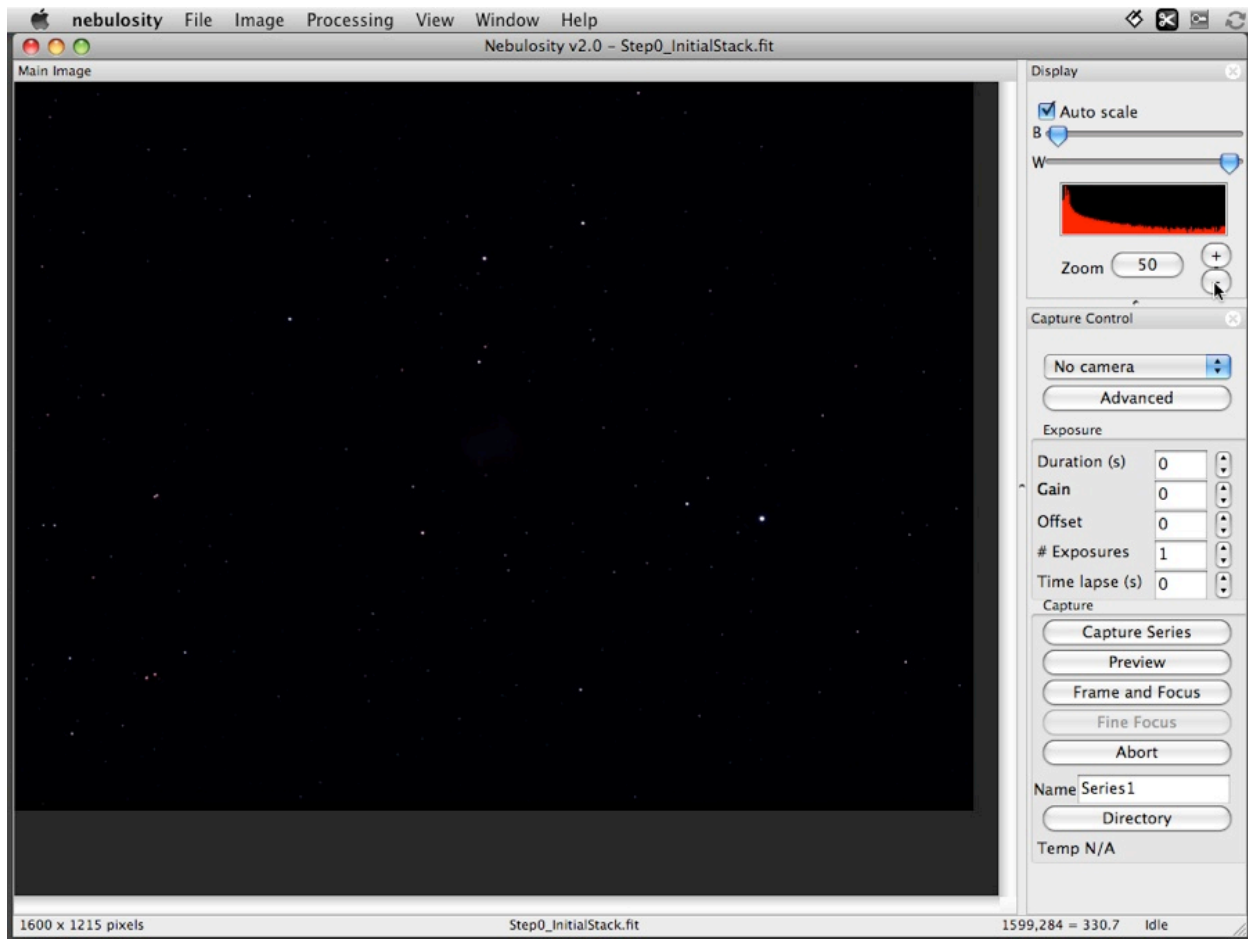

You'll see here the image is very dark. The histogram in the **Display** panel tells the tale. (This will be a recurring theme, so get used to looking at the histogram in the upper-right there.) Some may be tempted to turn off **Auto scale** use the **B** and **W** sliders at this point and make the image look like this:
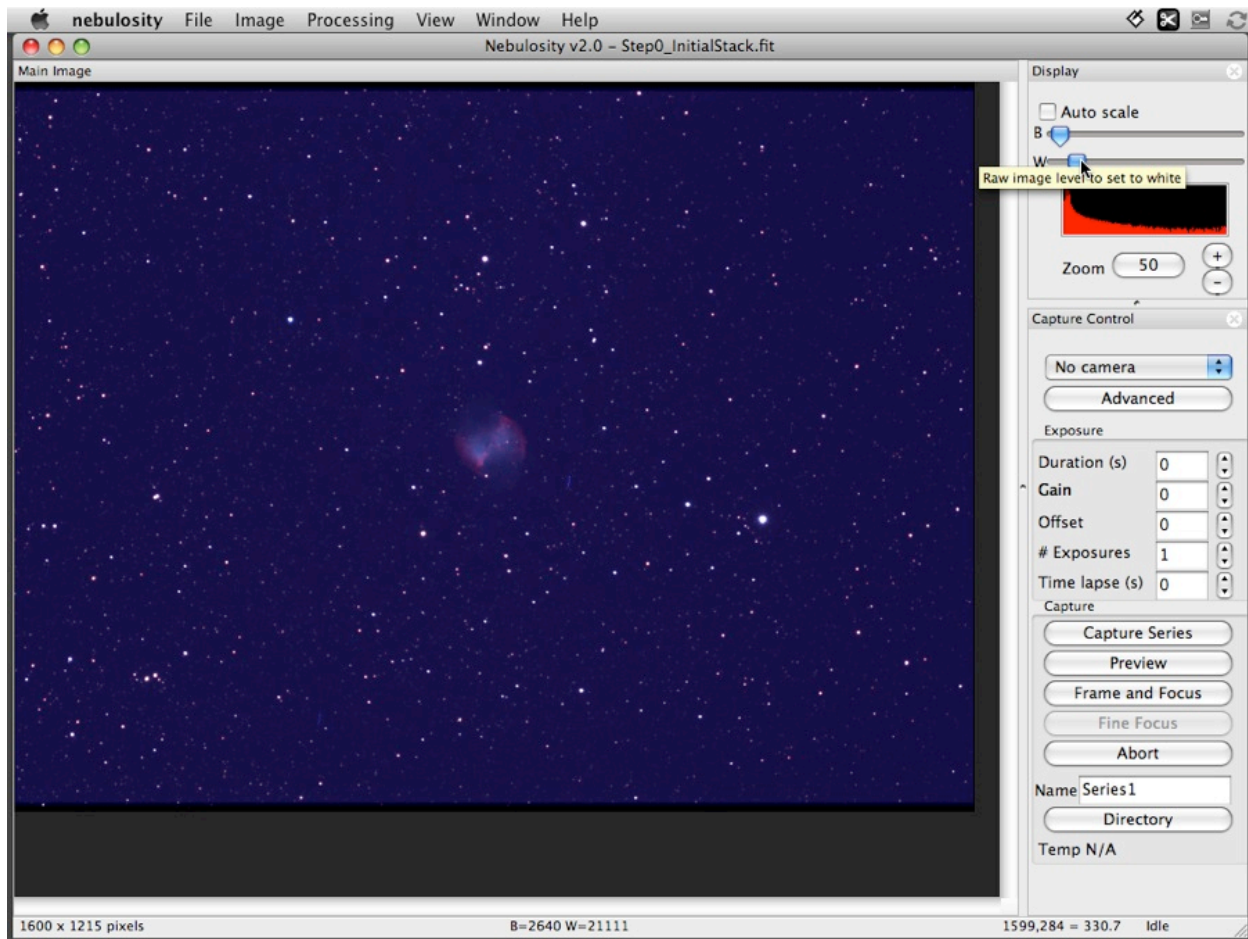
Notice how the display is brighter (ignore the purple cast for the moment, this was skyglow and my filter combining to give that hue) but how the histogram hasn't changed? Nothing has happened to the underlying image. Your data hasn't changed at all. What has changed is how the 16-bit (65536 shades of intensity per color) image is displayed on your 8-bit (256 shades of intensity per color) monitor. Imagine there is a photograph on your desk and the room is dark. The photo looks dark. Now imagine you turned on the light in the room. The photo looks bright. But, the photo hasn't changed. This is an important point. The **B** and **W** sliders don't change your image. Stretching with things like the **Levels** tool does, but they don't. They just change the way you see your image.

Step 1: Rough crop

At this point, I like to cut off the black edges that happen after stacking. The simple way is to simply drag a rectangle with the mouse and pull down **Image, Crop**. You'll note I left this with the B and W sliders set to better show where the real sky is and where the black borders are. If you crop here at this early stage, it can be handy to at least slide the **W** slider to the left so you can see that border. When done, save the image.
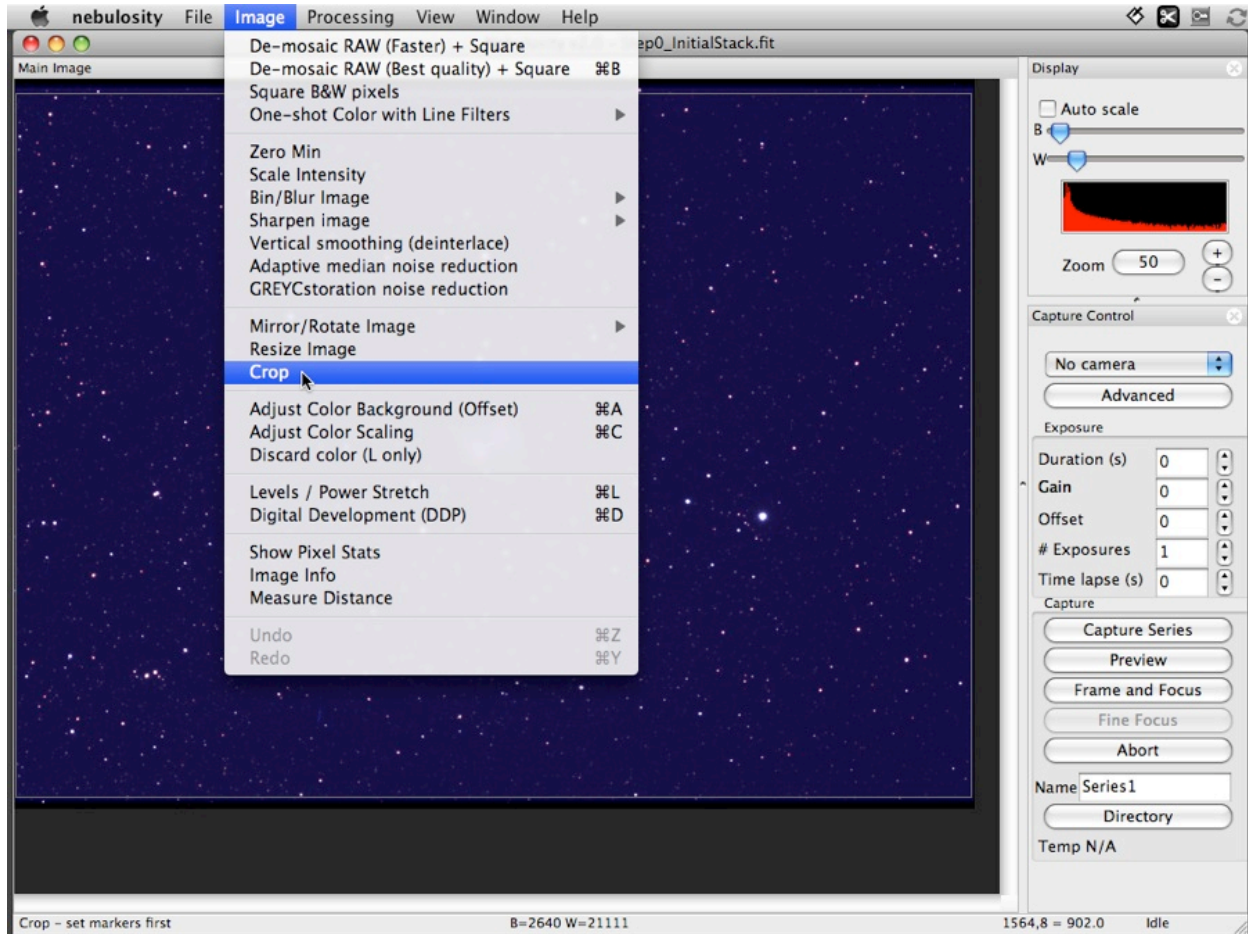
Step 2: Background Color

Almost all of us will have some color in the background. This comes from the skyglow and can be thought of as some color that is *added into each pixel*. The whole image has this hue resulting from the skyglow as the whole image has skyglow. So, we remove this by *subtracting something from each pixel*. In particular, we want to subtract (or adjust the offset) of each color. The **Image, Adjust Color Background (Offset)** tool does just this. The defaults work 99% of the time, so just stick with them. Save the file when done.
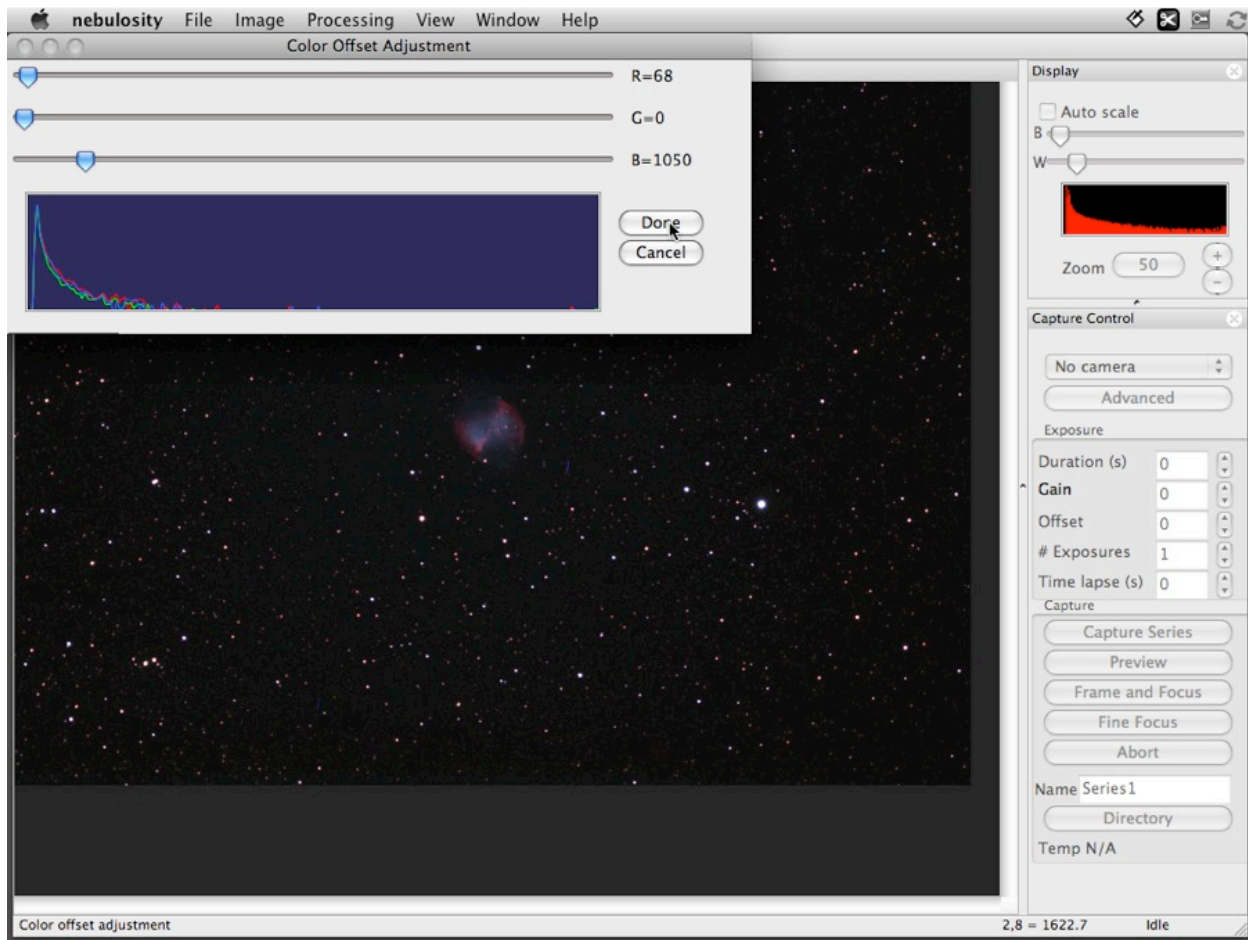

If you are curious, the sliders are showing how much to pull out of Red, Green, and Blue. The histogram on the bottom shows the histograms for each color channel. Note how they start and peak at the same point and how the sky is now a much nicer neutral color.

Step 3: Stretch

As noted above, we haven't really stretched the image yet. We've stretched the display of the image but not the image itself. **Levels** and **DDP** are two means of transforming the image (stretching it) so that we map the range of input intensities into a range of output intensities. Moving the B and W sliders here (or in the Levels tool) and nothing else is a *linear stretch*. If you know PhotoShop's "Curves" tool, it's the same has having a straight line with a different slope. It's also the same thing that Brightness and Contrast tools do. This can get us far, but we can get further with *non-linear stretching*. We'll try both Levels and DDP, starting with Levels.
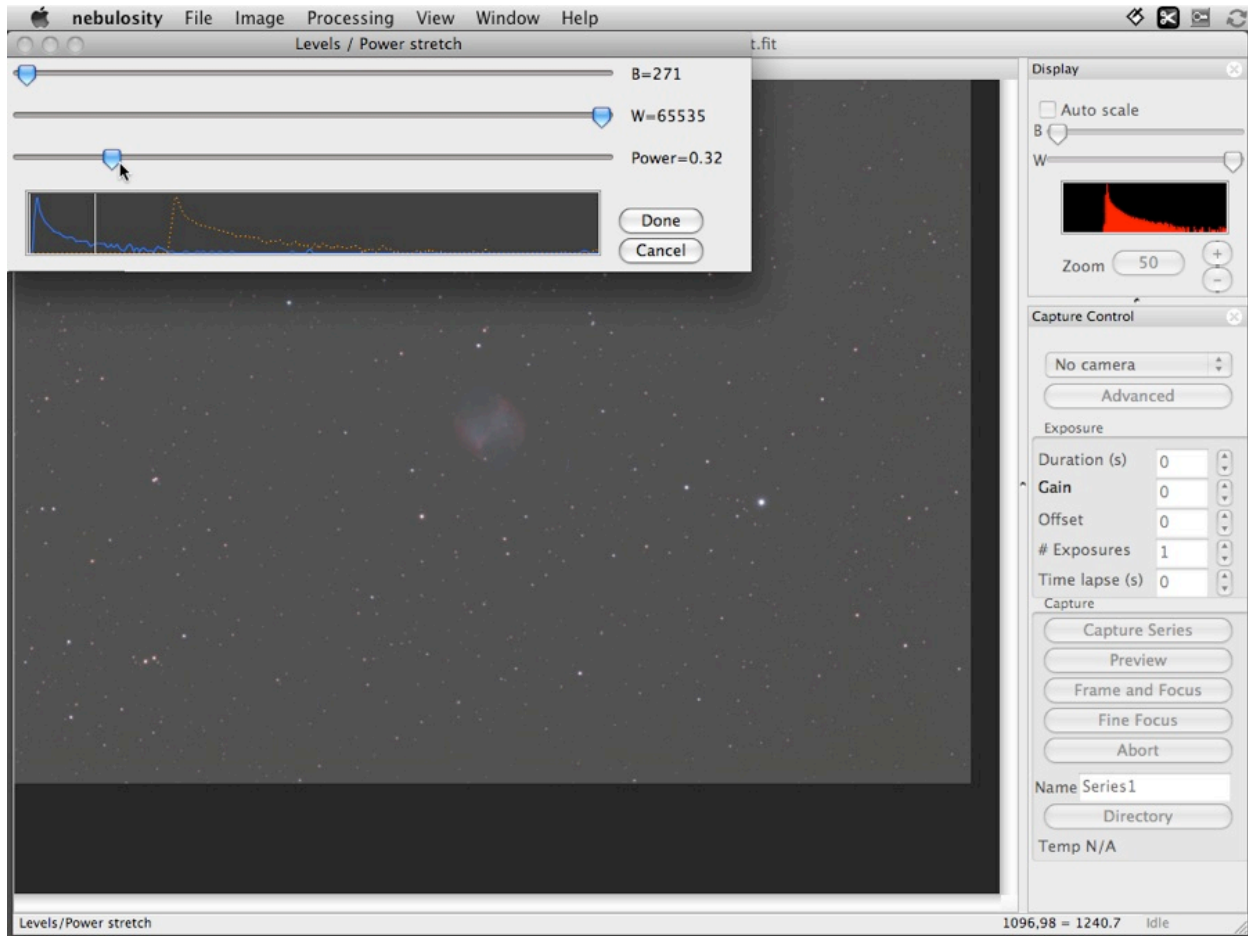
Levels Stretch

First, reset the image to **Auto scale** in the Display panel or move the **B** slider all the way to the left and the **W** all the way to the right so that we can see the full range of intensities that are really in the image. The, pull down Image, **Levels / Power Stretch** and a dialog appears with three sliders and a histogram. The sliders show the black (**B**) and white (**W**) points and the stretching power (**Power**). Note these are identical to the left, right, and middle controls in Photoshop's Levels tool. The histogram shows both before (blue) and after (orange) histograms. When we start, you should see the image as very dark like this:
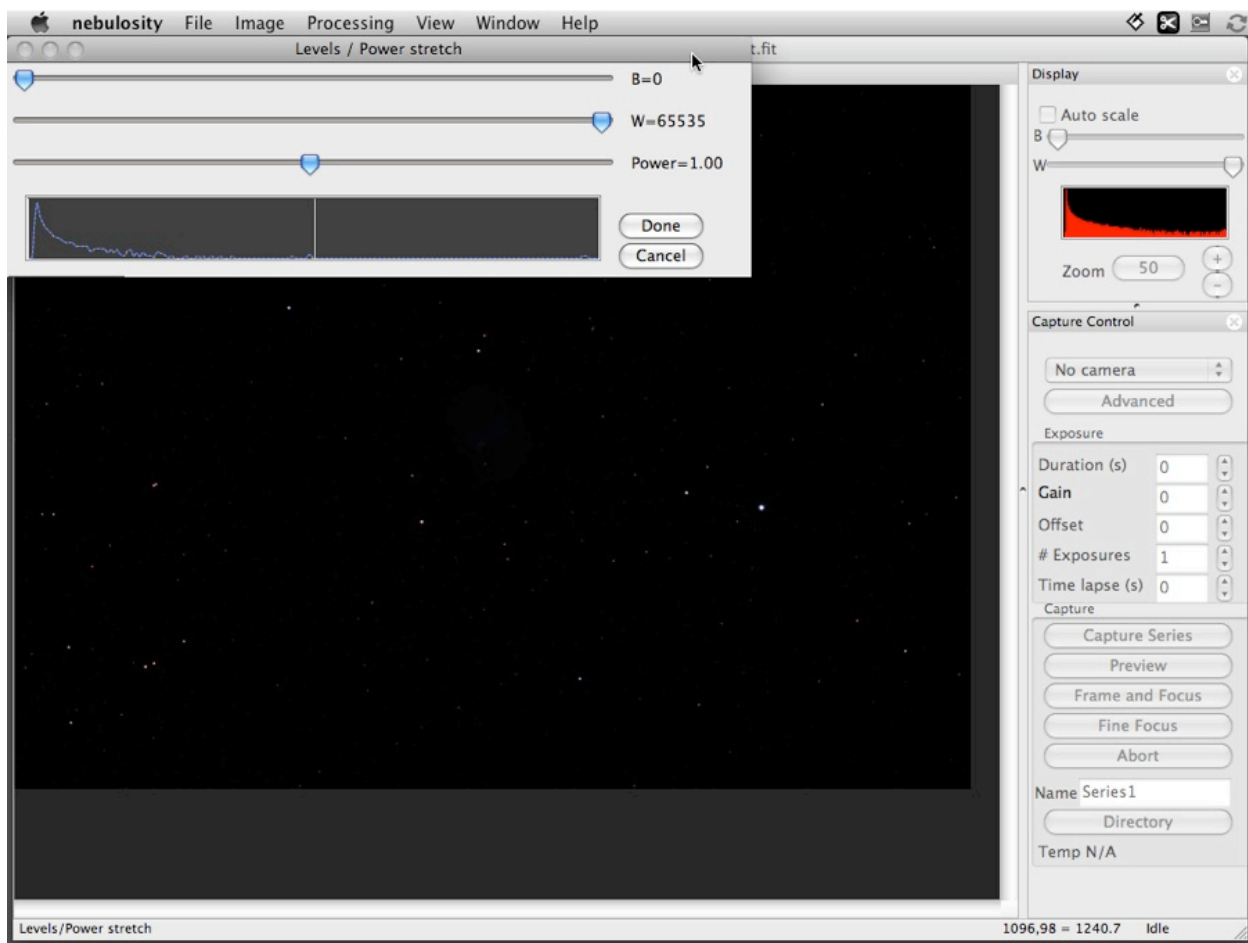
Move the **B** and **W** sliders around and you'll find a few things. First, the image gets brighter as you move the W to the left and darker as it goes to the right. The reverse holds true for the **B** slider. You'll see the "after" histogram move as you do this. You'll also see the *contrast increases as you bring the B and W sliders nearer to each other.* What you're doing is making a wide input range (0-65535) map onto a smaller range of intensities in the output. You are "stretching" the image. Note how the "after" histogram is broader here:
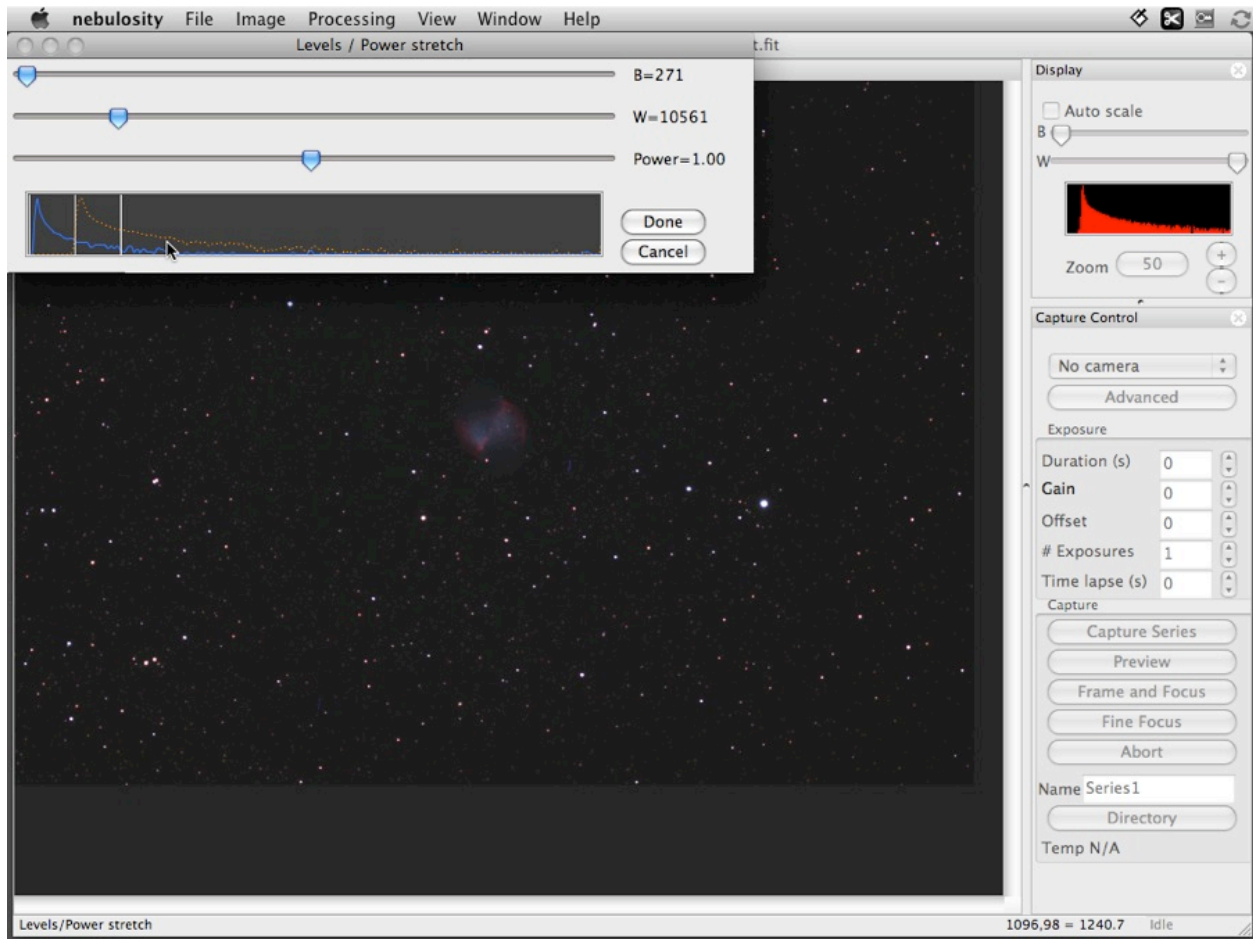
Don't be tempted to hit **Done** here just yet. We've brightened the image but we've also *clipped the highlights*. Everything above 10561 is now set to pure white (65535) by setting the **W** slider there. There is no going back from this. All "information is lost" above this level. Let's try another approach, adjusting the **Power** (midpoint):


This is better? Well, we've stretched things but it's certainly washed out. Hit **Done** and run **Levels** again. Now, slide the **B** up to set the black point near the bottom of the histogram. Don't cut it off or you'll loose data just like we would have on the bright parts.
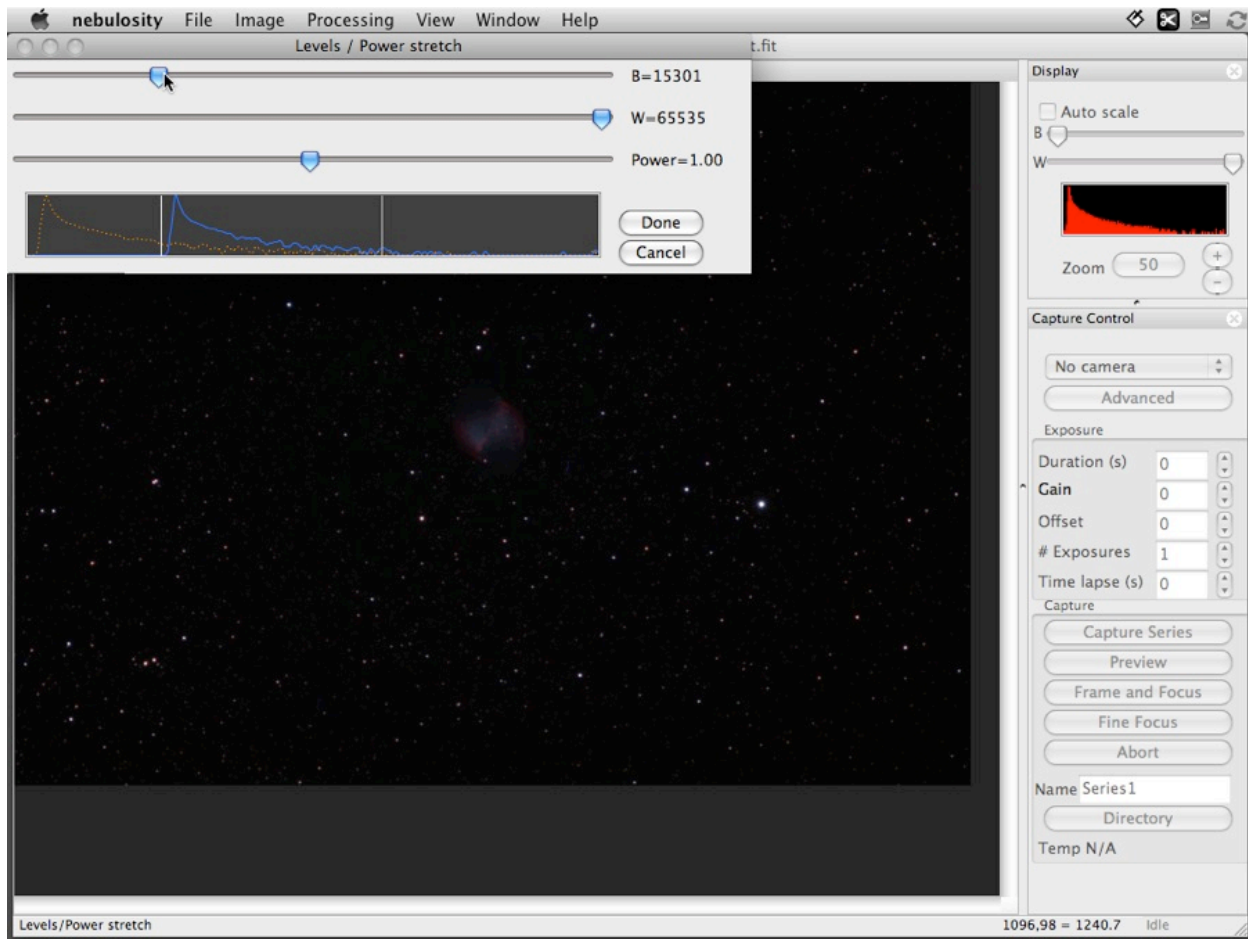
Better, but still dark. Run this through several iterations, slowly bringing out the data. Don't worry about doing it many times. Nebulosity keeps all data in 32-bit precision (floating point) per color per pixel. The data will stay nicely accurate as you stretch.

As you do this, feel free to clip a bit of the top end off if you like, but don't get too aggressive with the **W** slider and don't make the background a pure black either. That is, don't cut off much from the top (right) side of the histogram and certainly don't cut off the left.

After a few incarnations, I ended up with this:
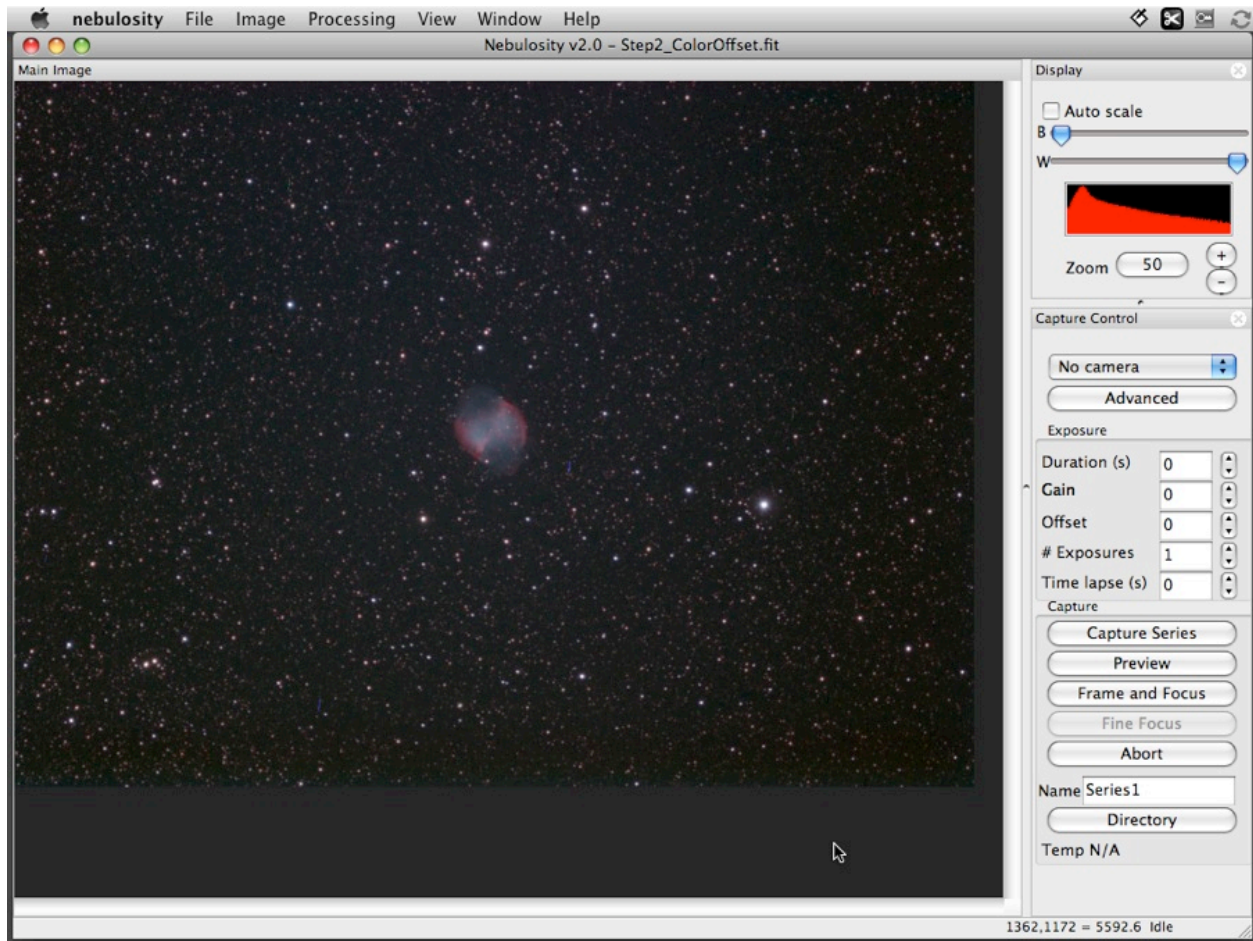
One feature to take note of here is the **History** dialog in Nebulosity 2.0 (**View, History**). This keeps track of everything you've done. For example, here it shows that I have done during Levels:

Levels: W=271 B=65535 Power=0.32
Levels: W=15301 B=65535 Power=1.00
Levels: W=948 B=57275 Power=0.50
Levels: W=6093 B=65535 Power=0.76
Levels: W=2843 B=65535 Power=1.00

Certainly save at this point (save early, save often – you never know when you'll want to restart from an earlier point in your processing).

DDP Stretch

If we go back to the image as it was before Levels, we can try another form of stretching, called Digital Development Processing (DDP). Don't try DDP after much (or any) stretching as it is designed to take the linear response of a CCD and turn it into the non-linear response of traditional film. When DDP is started, it tries to pick some defaults as shown here:
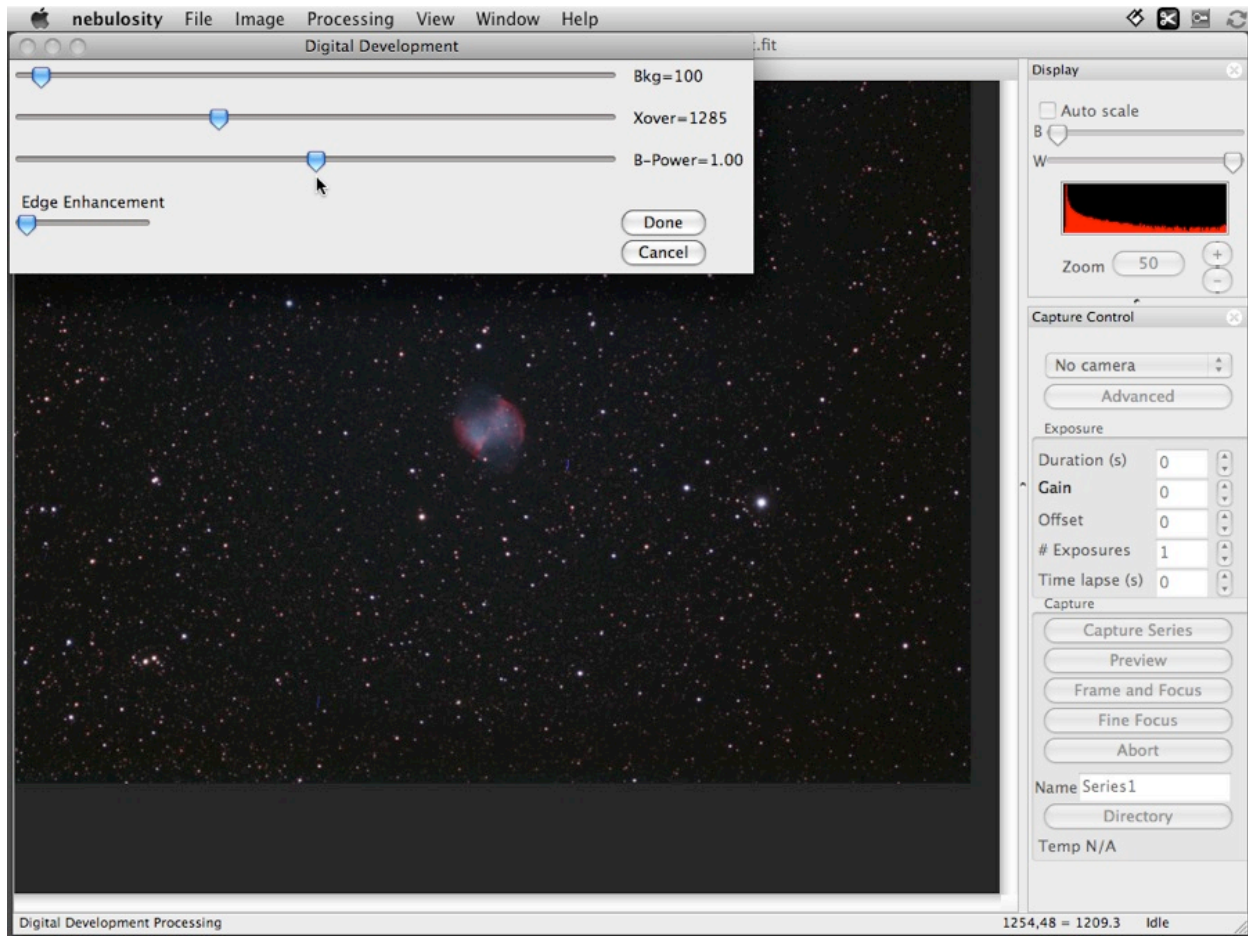

When DDP works, boy does it work! In one pass here we have a nice looking shot just using the defaults that Nebulosity came up with (it chooses values it thinks will be good for the image). You can adjust this a bit, spending most time on the **Xover** and **B-Power** sliders. The **Xover** controls where in the intensity scale (think where in the histogram) the DDP algorithm shifts between linear and non-linear operation. The **B-Power** slider controls a background darkening routine (not part of the official DDP algorithm, but one I like).

Step 4: Sharpening

At this point, you'll have an image that is starting to look like something real. There are a few things to fix up, however. We see there are a few colored trails here where hot pixels left a residue during **Align and Combine**. We wee that at the bottom of the image, there is an odd color artifact resulting from using an SBIG with a pick-off mirror for the guide chip and operating at a fast f-ratio. These are things to fix elsewhere (e.g., PhotoShop or any other image editor of your choosing). But, there are still some things we can do here in Nebulosity. Feel free to do go back and forth between other tools and Nebulosity. If you're using something that works at 16 bits per pixel or better (Photoshop does, but many do not) feel free to do so at any time. If your other programs only operate at 8 bits per pixel (24 bits in color), wait until after stretching to go into them to keep your data pristine. I usually use PNG or TIFF files to go back and forth as they preserve the data (they use *lossless compression*).

In Nebulosity, one of my favorite tools is the Star Tighten tool. Zoom the image in to 200% and we see the following:
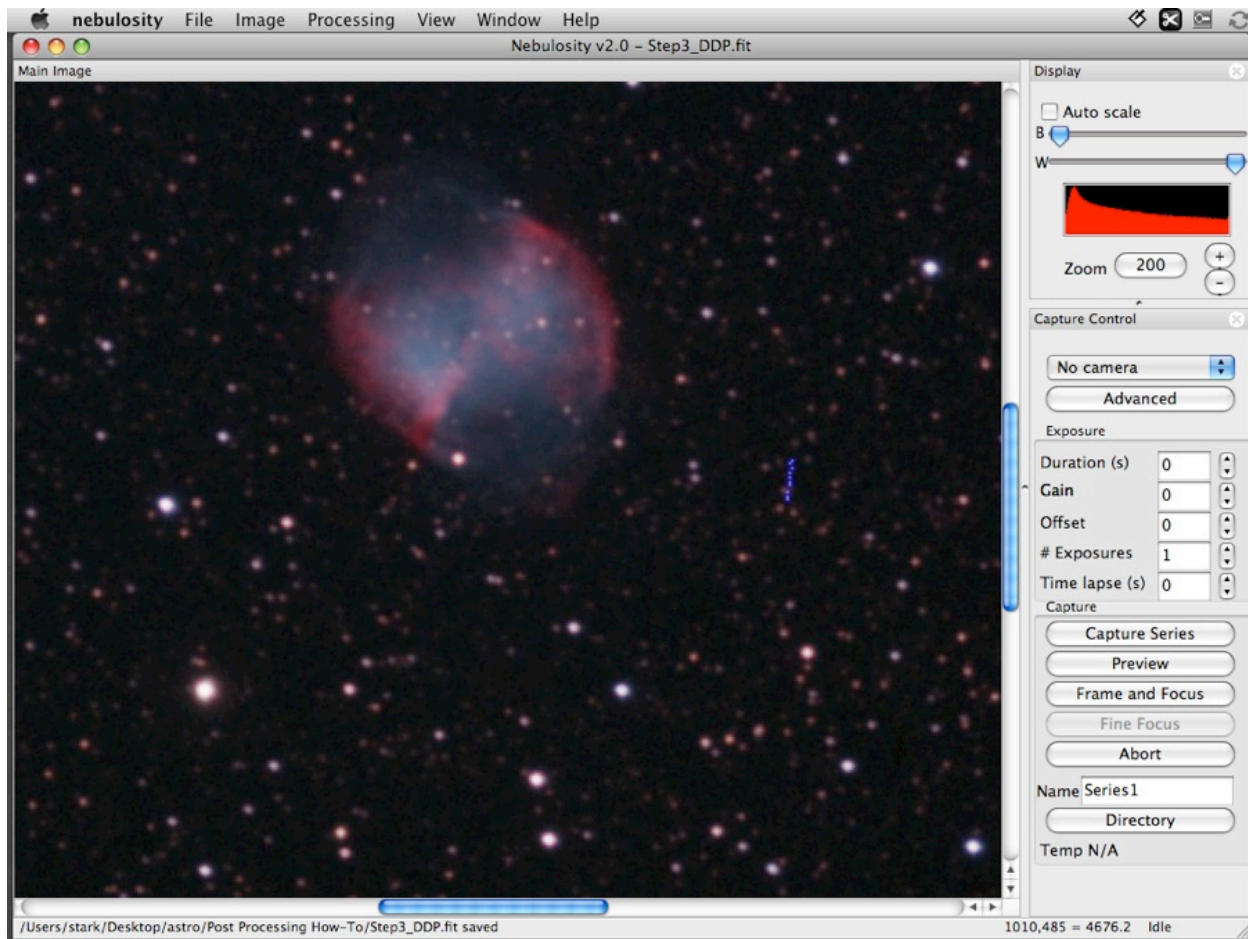
The stars are pretty clean and sharp as this is a wide-field shot and it's tough to get such wide shots very blurry, but we'll still see if a touch can't be done to clean it up. Pull down **Image, Sharpen, Tighten Star Edges (morphological)** and a dialog appears. 1.0 is the default amount of sharpening and 0.0 shows the unsharpened image. I find a value of 0.5 works well for this image:
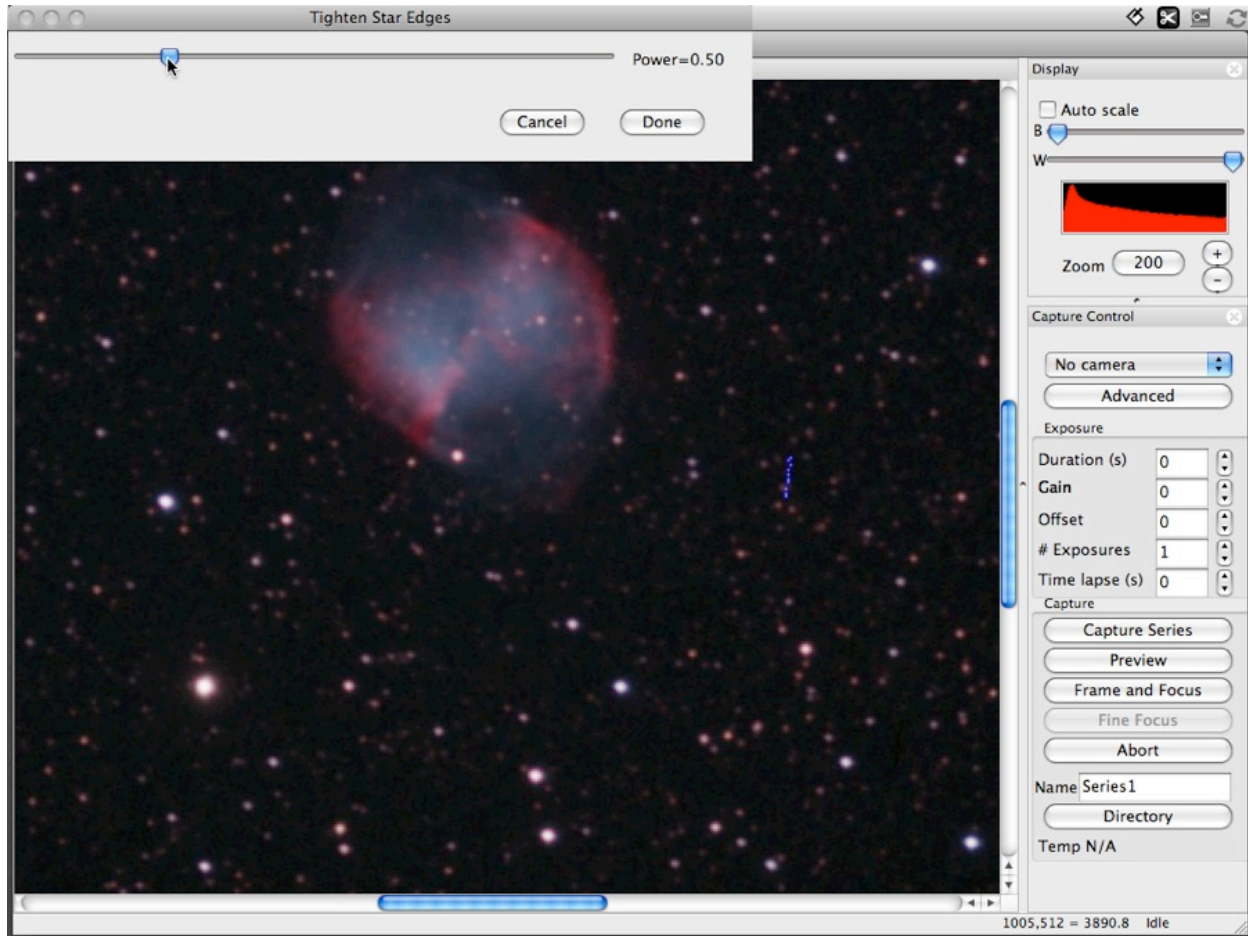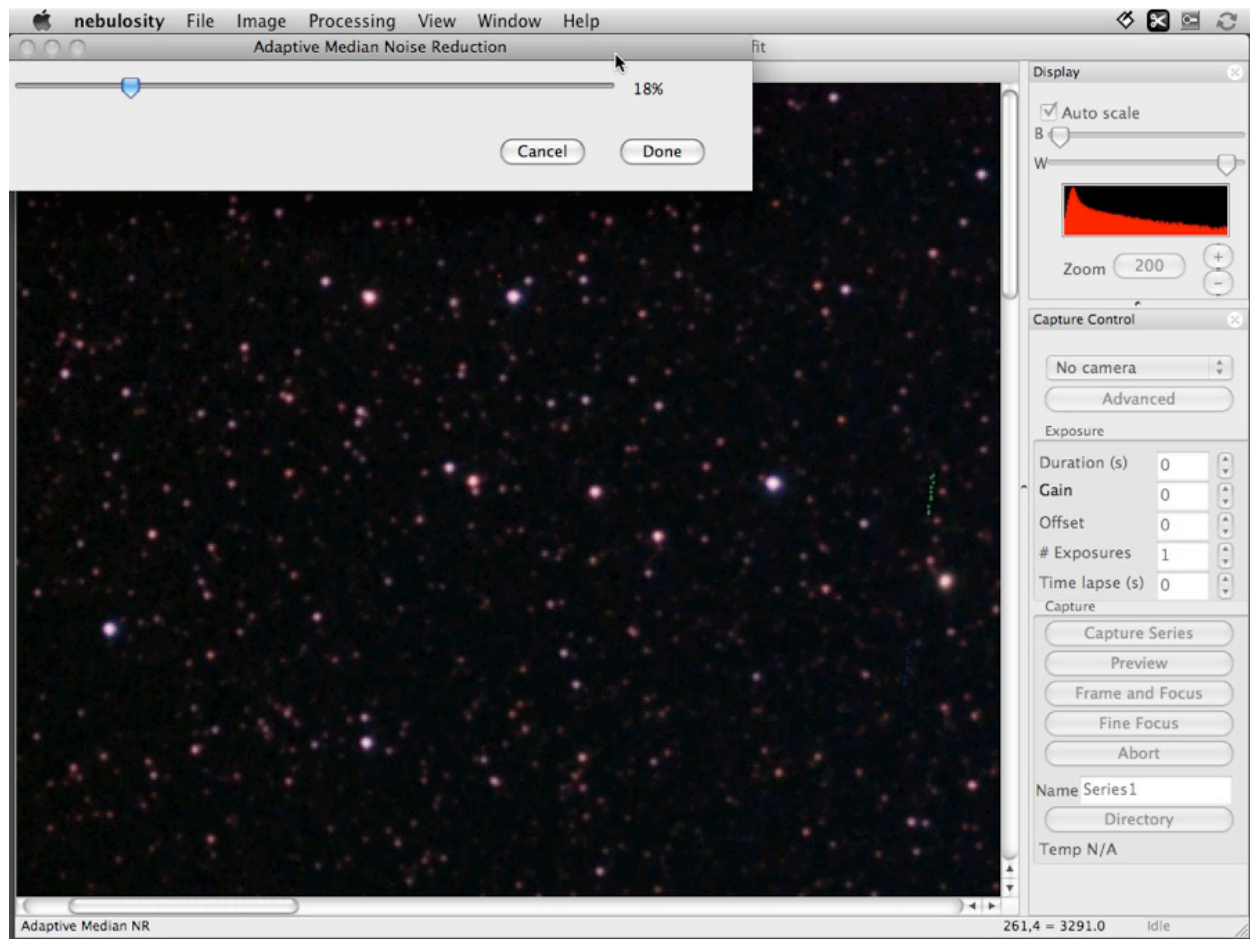
Step 6: Noise Reduction

Zoom in to 200% and you'll see a good bit of noise in the background. After stretching, we'll certainly see this. Nebulosity has several tools to cut down on the noise. The simplest is the **Adaptive median** tool in the **Image** menu. Here is a "before" shot:
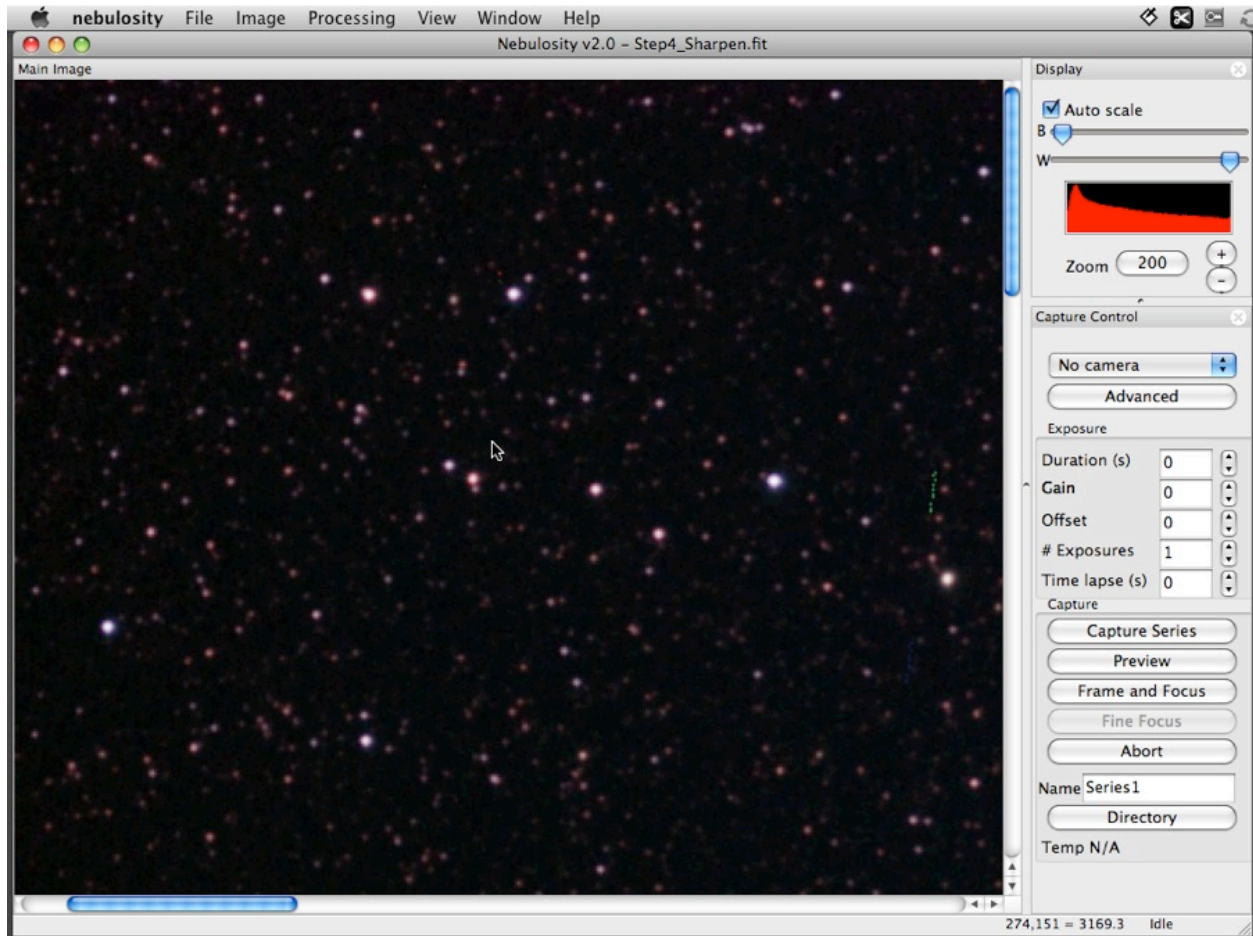
Pull down **Image, Adaptive median noise reduction** and a slider will appear to let you control the threshold for noise reduction. This lets you apply a median filter only to the background or faint wispy bits, leaving the stars more or less intact (at least more intact than a simple median filter). Here, I've dropped the threshold down so that the background stars are not filtered and just the background sky gets filtered.

Nebulosity 2 has a far more powerful noise reduction technique. Included in Nebulosity 2 is a copy of the GREYCstoration noise reduction application, dynamically called by Nebulosity. Its use is beyond the scope of this tutorial at the moment, however.

Final

Well, there we have it. We've gone from a stacked image to something ready for final touch-up work. Even if you don't have a copy of PhotoShop CS (or higher) and have something that is limited to 8-bits per color, you're now at a point at which it is safe to bring it in (use TIFF or PNG again) and touch up any defects like those niggling hot pixel trails. Nebulosity has done the heavy-lifting as it were with 96 bits per pixel (32 bits per color) in full floating-point math, so every detail that was in the image remained in there during processing.

Good luck and clear skies!