

# High Dynamic Range Processing

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Deep sky astronomical Images are produced by capturing and building up very faint signals over an extended period of time. Although faint, some objects produce a wide range of signal intensity between the very brightest and the dimmest parts of an image. For instance; capturing bright detail of the surface of the Sun and displaying it alongside the exceedingly fainter prominences on the edge of the solar disk demands expert management of the very high dynamic range of brightness values. Currently, modern digital cameras can manage broad dynamic range in terrestrial scenes by taking several images at different exposure settings and then combining these exposures to make a coherent image. High Dynamic Range (HDR) imaging and processing are now the catch terms that refer to imaging and processing techniques that effectively manage high dynamic range data to produce images with high visual and informational impact.

HDR processing has been around for a long time. Ansel Adams used darkroom techniques to employ “dodging and burning” of specific zones to present his famous HDR images in very dramatic and memorable photographic prints. Today, even the iPhone can “auto”-produce HDR images, and high-level video cameras are beginning to deploy HDR principles to videography.

We live in a golden age of astrophotography. Today we enjoy a wonderful array of tools to help us manipulate the range of intensity, contrast, and detail of information we display in our images as digital renderings. The photographic tools of today are contained in an array of sophisticated graphic software programs such as Adobe *Photoshop* and *PixInsight*. Mastering HDR digital processing with Adobe *Photoshop CS5* will be the main focus of this chapter.

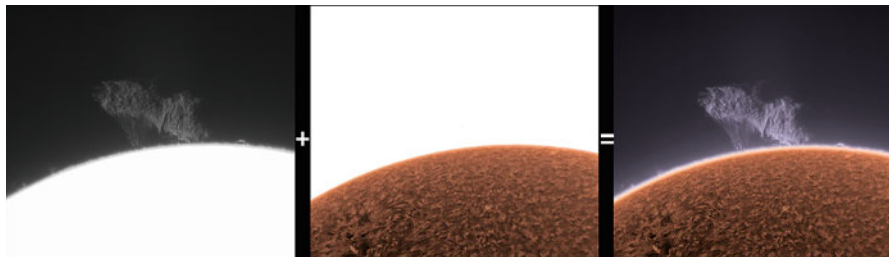
## Combining Different Exposures

Typical HDR images are made by merging two different images of the same subject using different exposure settings to display a higher dynamic range than the camera can produce using only one exposure setting. Normally, this type of merger is accomplished in post processing software for astronomical images. A simple example would be combining an image containing very bright solar disk detail with another image of much fainter prominence detail to produce a final image that reasonably displays both at the same time. To capture the prominence I had to overexpose the solar disk. Next, I adjusted the camera settings to record the surface details as a second image. Then, using Masks, I combined the two for the final result (Fig. 1).

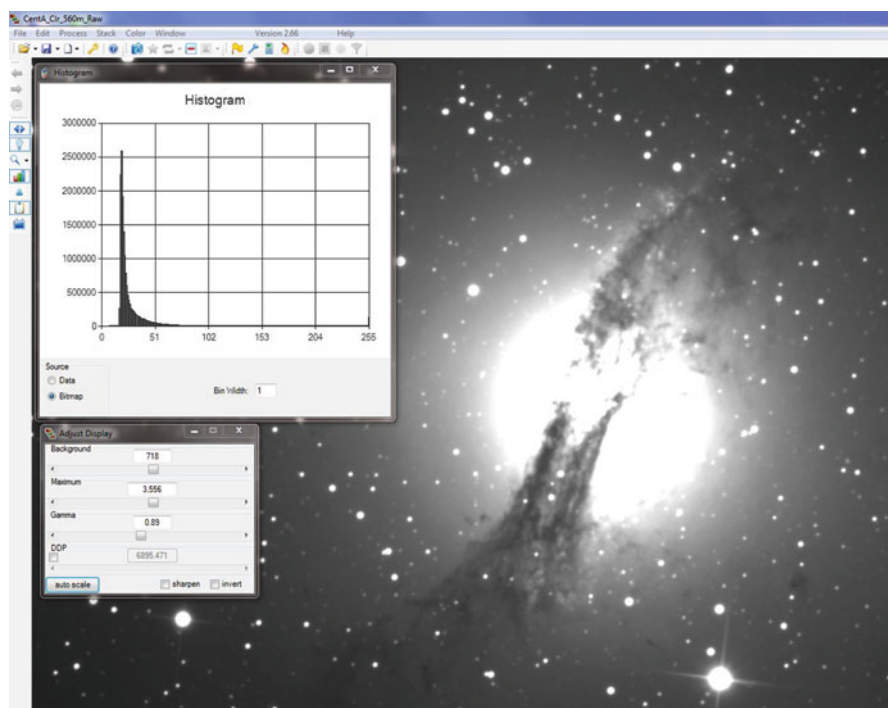
Practically speaking there are really very few deep sky targets that require separate exposures to capture the faintest regions of the object. The great nebula in Orion (M42) and Eta Carina are two that come to mind, but often the dynamic range of deep sky objects can be managed effectively to display the faint and bright areas in a single image or stack of images. If it cannot, then using selective processes to blend the details of two differently exposed images is the most effective way to go. “True” HDR images are produced by merging two or more images taken at different exposures or F stops. There are software programs out there that can accomplish this type of process, but what astrophotographers traditionally do is simulate HDR by controlling the dynamic range with selection, stretching, and toning tools.

## HDR Tools

Currently some of the most popular HDR tools for astrophotography are DDP, HDRWaveletTransforms, mask stretching, and tone mapping. I have always believed that you cannot have too many tools in your processing toolbox, and it is very worthwhile to explore all the possibilities and find the methods you are most



**Fig. 1** Overexposed disk with prominence combined with the surface details



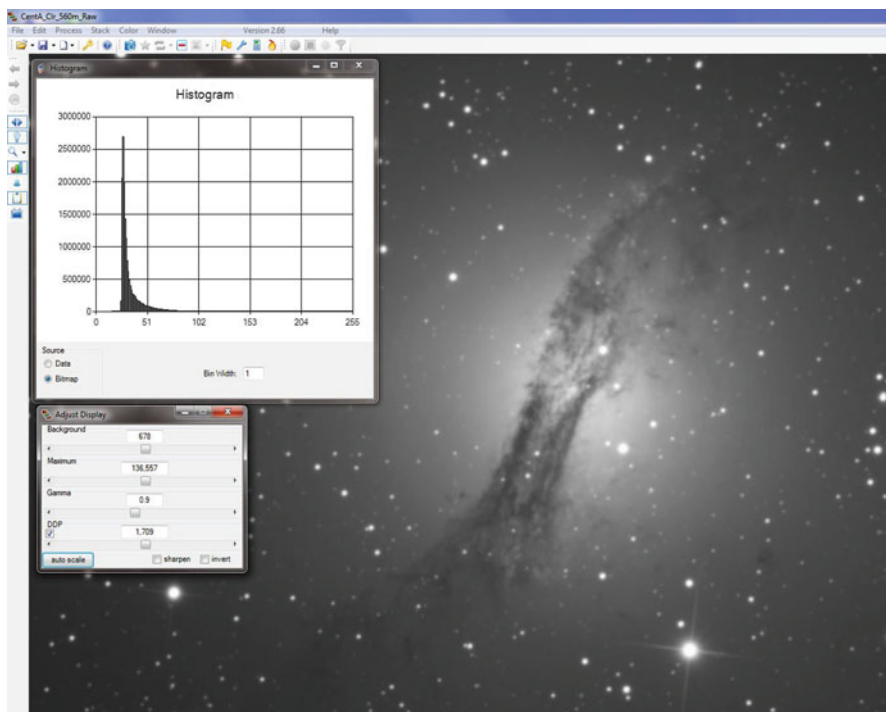
**Fig. 2** Linear stretch until the dust lane is revealed

comfortable with. Remember that these are powerful processes, and you can use them with the precision of a surgeon's knife or a blacksmith's hammer.

DDP, or the "Digital Development Process," is a brightness scaling method that compresses or squeezes the large dynamic range of a CCD image to display the faint regions while maintaining control over the bright areas. There are several DDP software tools out there. I prefer *CCDStack*, as I can nicely control the final result with a real time full screen preview of the image. One thing you need to watch out for when using DDP or tone mapping tools is not to over-compress the dynamic range and end up with less contrast and a flat-looking image.

Using *CCDStack's* DDP, you use the Adjust Display parameters while watching the histogram. The adjustments happen in real time to the display image and do not affect the underlying image data. Therefore you can manipulate the image to let you scale the brightness values to show the faint areas while at the same time control the top brightness values. In Fig. 2, you see the galaxy displayed in a linear stretch scaled up in brightness until you can see the fainter parts of the dust lane. As you can see, the core area is blown out and details are lost in the brighter regions.

Checking the DDP box turns on the DDP adjustment slider and control over the scaling of faint areas. Pushing the DDP slider to the left increases the brightness of



**Fig. 3** The DDP button is checked to turn on the DDP adjustment slider

the faint areas and the compression of the dynamic range. Using the gamma and background sliders controls the histogram pedestal and clipping. Just make sure there is good shoulder room on the left side of the histogram. The Maximum slider is a progressive adjustment that controls the scale of the brightest pixels. Monitor the brighter structures and stars and the height of the histogram when making adjustments to the maximum values. Then adjust the DDP slider until you see the fainter details just start to show, as in Fig. 3.

You can almost simulate this type of a stretch using Levels and Curves in *Photoshop*, but it is not a one-step process, and DDP is much easier to use to produce the final result.

Using only DDP will help you display a larger dynamic range, but you also need to provide some type of sharpening and contrast adjustments or the image will appear a bit flat. You can accomplish those enhancements later in *Photoshop*. Once you have the DDP adjustments to their proper settings, you must save the image as a scaled file so it retains the values. Just be sure not to overwrite your existing pre-DDP file.

*PixInsight* has a very powerful process called HDRWaveletTransform that employs a wavelet method that selects parts of an image based on the features scale

while breaking them up into layers. Then contrast adjustments can be made to those isolated structures. Very nice results can be produced if the program is managed properly.

## HDR Toning Tool

True HDR requires the merging of multiple images taken at different exposures or bracketed images using software such as *Photoshop CS5*. This software compresses the tonal range of multiple exposures into one image. But that is just the first step, as squeezing the tonal ranges into a smaller area can soften the look and flatten the contrast. You can simulate the HDR look without the work of producing multi images taken at different exposures. The HDR Toning Tool introduced in *Photoshop CS5* can really give you some very interesting results.

There is a bit of a learning curve with this tool, as there are several adjustments that can be made to affect the outcome of your images. The first thing that I always do is to duplicate the image that I am working on. This is because the HDR Toning tool works in 32 bits, which gives you a larger range to work with. But the monitor cannot display the complete range perfectly, so this will not work with layers and will need to flatten the image if it has layers. Once you duplicate the image, you can then find the HDR Toning tool in the Image – Adjustments – HDR Toning (Fig. 4).

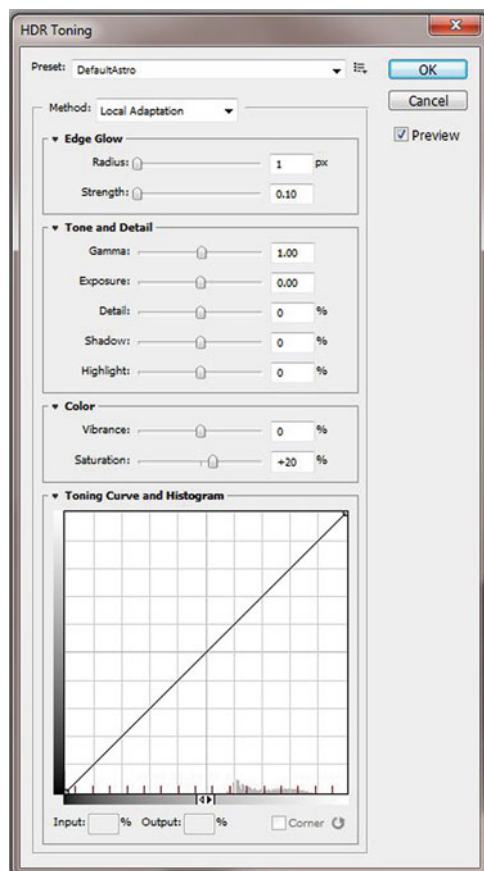
Make sure all of the adjustment sliders are in their neutral positions and the Method is set to Local Adaptation. You can save this as a pre-set so you can load it up later. First let's break down each of the adjustment boxes.

The Edge Glow box controls the adaptation size and the reach of the adjustment halo in pixels. The Radius and Strength sliders work together to expand or contract the size and power of the adjustments you leverage in the Tone and Detail control box (Fig. 5).

The Tone and Detail control box makes adjustments on the luminance levels. The Gamma slider adjusts the midtones while the Exposure slider adjusts the white point. Use these very carefully, as a little goes are very long way. The Details slider is a very effective sharpening tool and is used in concert with the Edge Glow controls. Use lower strength and radius values to tighten smaller scale structures while stronger strength and radius values will go after the bigger ones. I will normally make my contrast and toning curve adjustments first before going after any details.

The Shadows and Highlights add very fine adjustments to the dark and light areas of the image. You will normally have to pull down the highlights a bit on deep sky images to bring the brightest areas into a normal range in order to avoid bright detail being “blown out.”

You can make saturation color adjustments using the Vibrance and Saturation sliders under the Color control box. Vibrance uses relative scaling, which was meant to protect skin tones while you brighten the colors around them. Saturation provides equal scaling to all the pixels so a combination of both seems to work the best.



**Fig. 4** HDR Toning tool

The Toning Curve and Histogram is where I normally start when using the HDR Toning tool. When you first open up this tool your image will look terrible as it is applying a default pre-set. I recommend that you set all the sliders to their neutral or lowest settings and save that as a pre-set. You can then load this pre-set to begin working on your image.

Once you have your sliders at neutral then begin by pulling the top of the Toning curve straight down along the right side of the control box. As you do this, keep your eyes on the brighter stars and make the sure they do not appear blown out. Then use the Shadows and Highlights sliders to make fine adjustments using the eye dropper tool to sample the areas that appear to need attention. You can place anchor points for the Toning curve with the eye dropper tool with **CntL+Alt+Click** (Fig. 6).

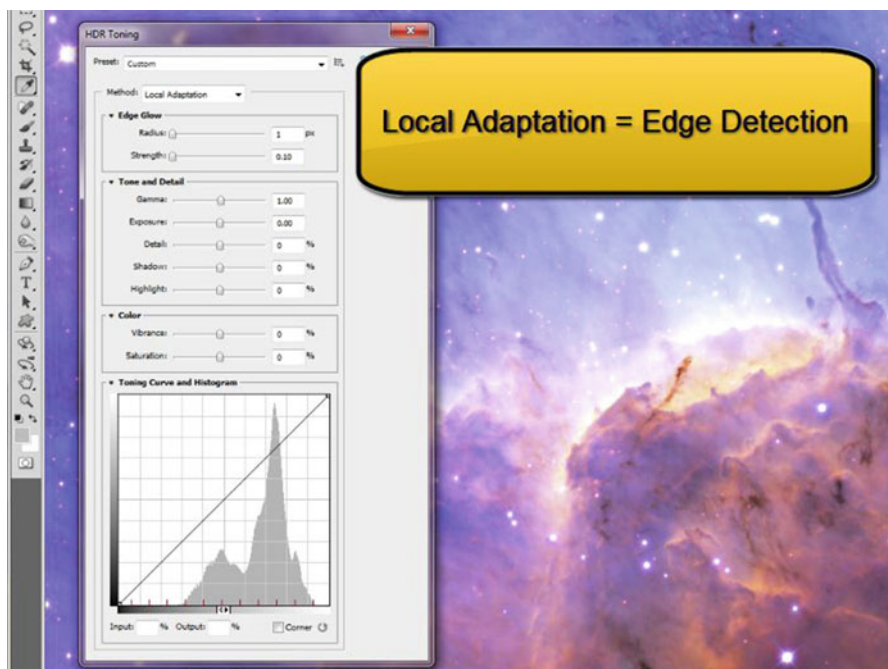


Fig. 5 HDR Toning

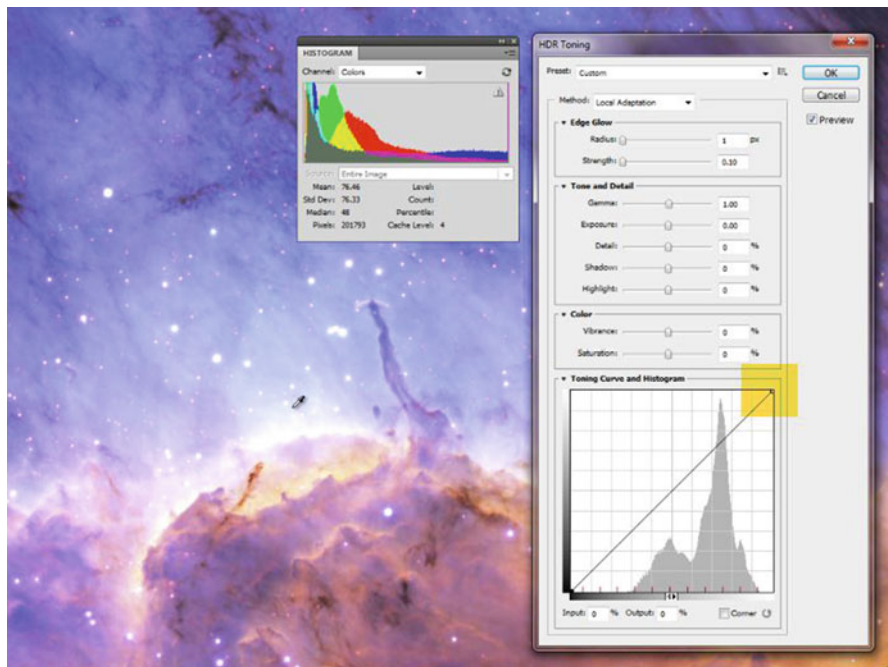
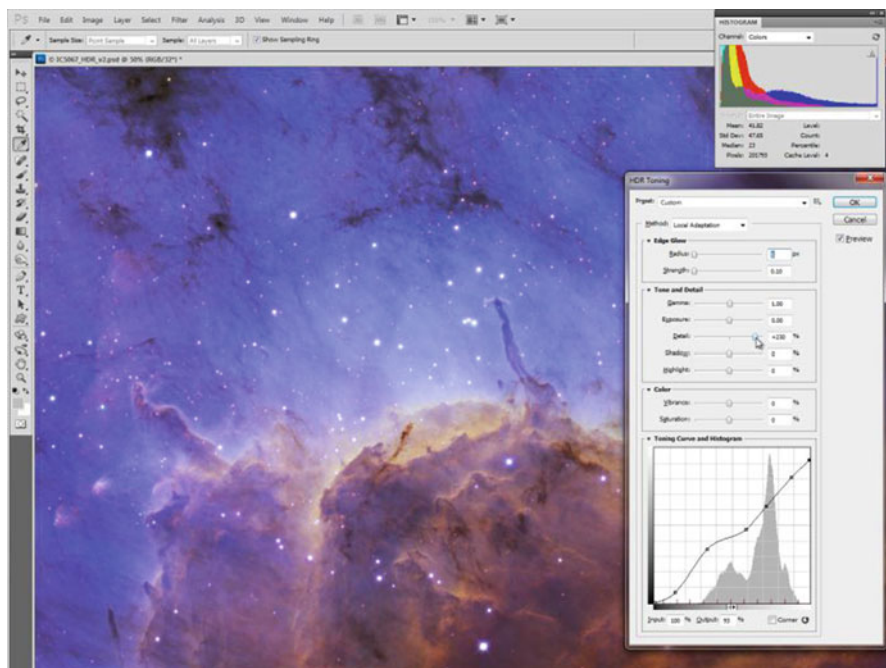


Fig. 6 Start with the Toning curve adjustments





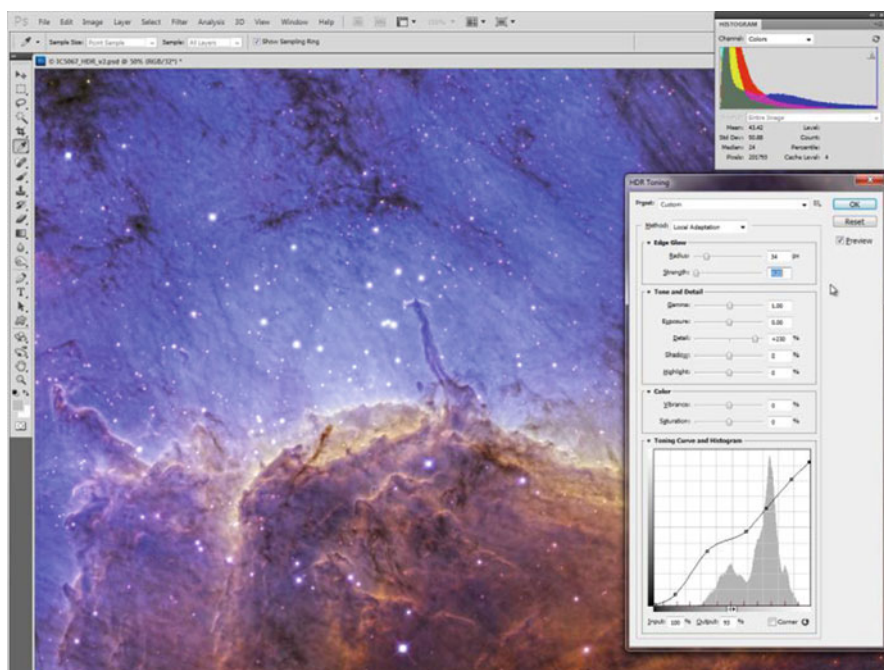
**Fig. 7** Toning curves with adjustments

I normally place anchor points at the highlights, midtone, and shadow areas. Selecting an anchor point then allows me to use the up and down arrow keys for small changes to the curve. Keep making adjustments to the “Toning curve” until you have the highlights protected from being over cooked and good contrast in the midtones and shadows areas as demonstrated in Fig. 7.

Now is a good time to explore the “Details slider,” which controls edge sharpening and contrast. This slider works in concert with the Edge Glow control box. I like to first increase the Detail slider up to 100 % so I can easily see the changes as I expand the adjustment halo.

For small-structure details use a small radius and go light on the strength. Then expand your reach by increasing the “radius” a little at a time to include the areas of interest. Increasing the strength applies the sharpening and acts a little like a fine adjustment knob for controlling the strength of the Details slider. You will notice contrast enhancements as the edges become more and more defined. This will take a bit of practice, and you will need to make small adjustments until you feel the right structures are included and defined. Once you are ready, move the Details sliders back and forth until just the right amount is applied to taste. It is a good idea to keep an eye on the histogram and the channels panel to ensure you do not create too harsh of an effect and blow out a color channel (Fig. 8).





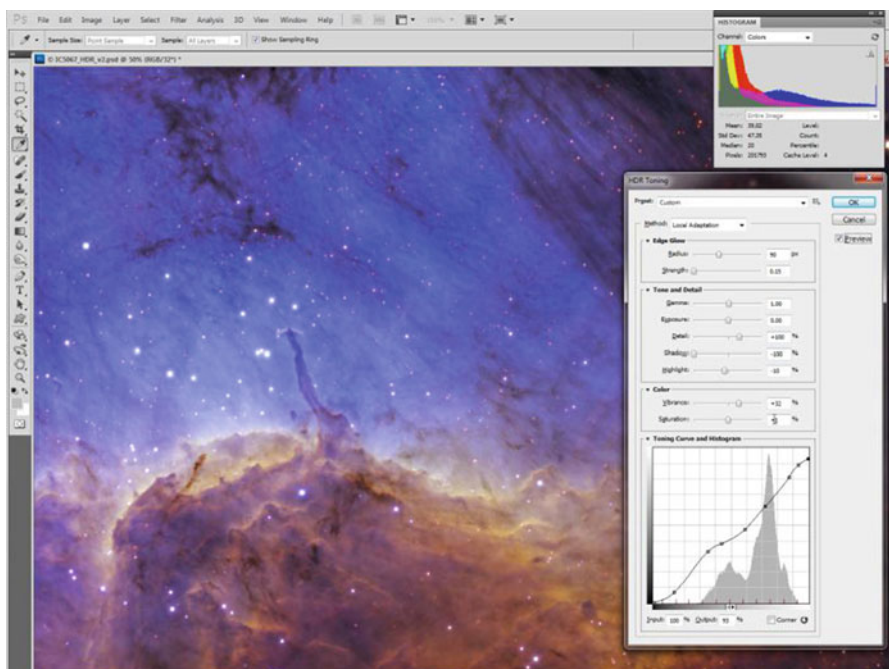
**Fig. 8** Detail and edge glow adjustments

You can tweak the saturation and vibrance at this point as well as fine tuning adjustments to the Shadows and Highlights. Once you are done, it would be a good idea to save the pre-set in case you want to return to this subject later. I have found that each image demands its own special setting, and I normally have to start from scratch every time (Fig. 9).

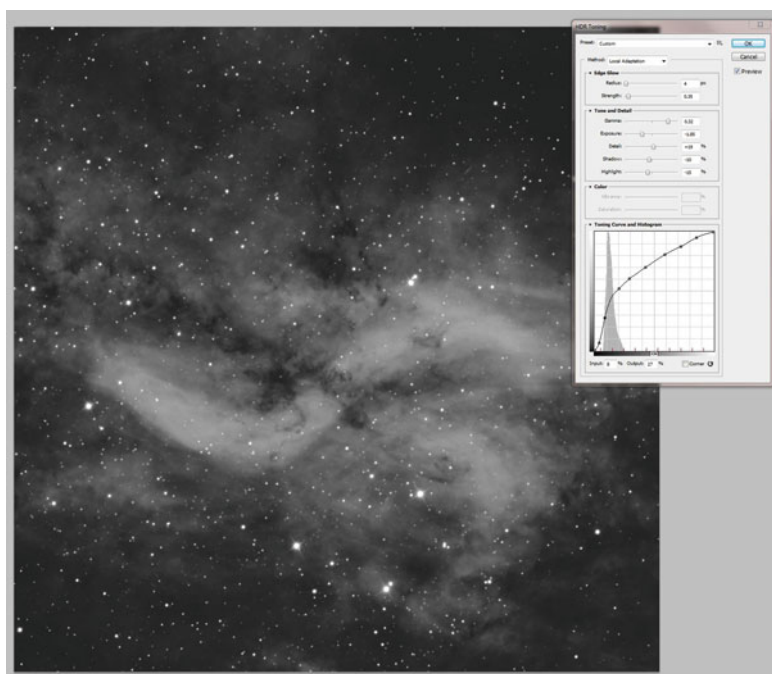
Now I will copy the HDR Toning adjusted image and paste it as a layer on top of the original image, where I can adjust the opacity to taste.

Because the HDR Toning tool works in 32 bits you can use the tool to bring in 32-bit FITS files for processing. You will need a FITS plugin like Eddie Trimarchi's FITS Plugin 2.0 so you can open up the 32-bit FITS file directly in *Photoshop CS5* or later. You can use the same methods I have described using the Toning Curve and Details enhancements to provide a nicely stretched and sharpened image ready for color mapping. This works best on narrowband data where you want to bring out contrast and details on each separate channel. The difference here is you want to open the HDR Toning by going to the *Photoshop* menu to Image – Mode and select 16 bits/Channel. This will allow you to make your toning adjustments in 32-bit, but then it will convert the image to 16-bit so you can utilize all of *Photoshop's* tools, as most do not work in 32-bit space (Fig. 10).

The more you use the HDR Toning tool, the better you will like it, and you will find that it gives you amazing control over a very wide dynamic range.



**Fig. 9** Ready to save as a pre-set



**Fig. 10** A 32-bit Ha FITS file opened with the HDR Toning tool

## Using Star Masks to Boost Dynamic Range

When there is a very faint signal in an image that you would like to display, one of the common challenges is to display the faint structures without destroying the nice star profiles. If you over stretch the stars a host of negative effects can emerge, including fuzzy edges, color fringes, and bloated star sizes. One way around this is to produce a star mask to protect the stars while you increase the brightness of the faint areas you wish to highlight. You can also use this mask to isolate the stars from over saturation and sharpening. In this example I am using NGC225, which is a beautiful star cluster that also comprises some amazing gas and dust structures that are very faint. Since the stars are a very critical element of this composition, I want to make sure they are the focal point, but also emphasize the supporting structures and background containing the intriguing faint features of reflected dust and gas.

You can build a star mask in several ways, and the goal is to select the stars and protect everything else. One effective way is to first go into the “Channels” panel and select the channel that has the most contrast between the background and the stars. Then under the menu Select tab choose Color Range. This will bring up the color range tool box that controls the selection process based on the type of sampling you want to use. I could use the “eye dropper” to select the range of pixels I want to use, but many times I will use the drop-down box to automatically select a range of brightness values. So here I want to select the Shadows, which is all of the dark signal, then invert the selection and save it as a mask by clicking on the mask button (Save selection as a channel). This will give you a black and white alpha channel that contains the mask that we can refine and use as a layer mask (Fig. 11).

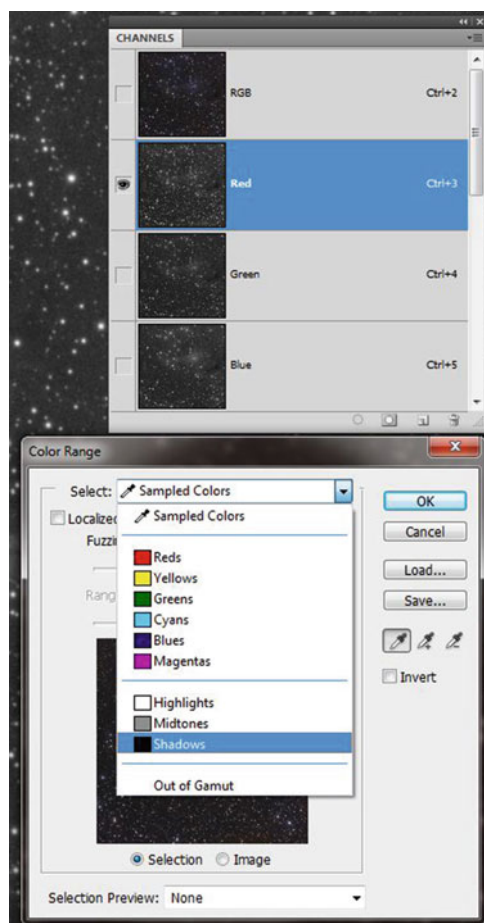
Once you have the alpha channel with the mask, rename it using a term that will remind you that this is the raw star mask before any refinements. Now we can begin to use this mask to protect the stars as we brighten and enhance the fainter things around it (Fig. 12).

Let’s go over the steps to make this mask useful:

1. Select the Layers panel and then duplicate the layer.
2. Select the Channels panel and select Raw Star Mask alpha channel that we created earlier.
3. Load the mask as a selection by Ctrl+Clicking on the alpha channel that contains our mask. You will see the “marching ants” circling our stars.
4. Select the Layer panel and then select the top layer. You will see the marching ants have transported it to the top layer.
5. Click the “Add Layer Mask” button at the bottom of the layer panel. The marching ants will disappear from the main image and produce the layer mask linked to the top layer.

Another way you can do this is to:

1. Select the alpha channel that contains the mask and select all (Ctrl+A) then copy (Ctrl+C).



**Fig. 11** Selecting the stars from the red channel

2. Select the Layers panel and Alt+Click the “Add Layer Mask” button at the bottom of the layers panel. This will produce a blank Hide All layer mask.
3. Alt+Click the layer mask then paste (Ctrl+V).

Either way will get you to the same place, and that is a layer mask that we can now refine and start to make adjustments to (Fig. 13).

To reveal the fainter structures hidden in the background and have some control over the stars we need to add a few adjustment layers to leverage the power of the mask.

First duplicate the layer with the mask and say “yes” to the “apply” mask option. We want a copy of the layer with its associated layer mask. Name the middle layer ‘Brighten Background,’ as this is the mask we will use to protect the stars and pump up the background (Fig. 14).

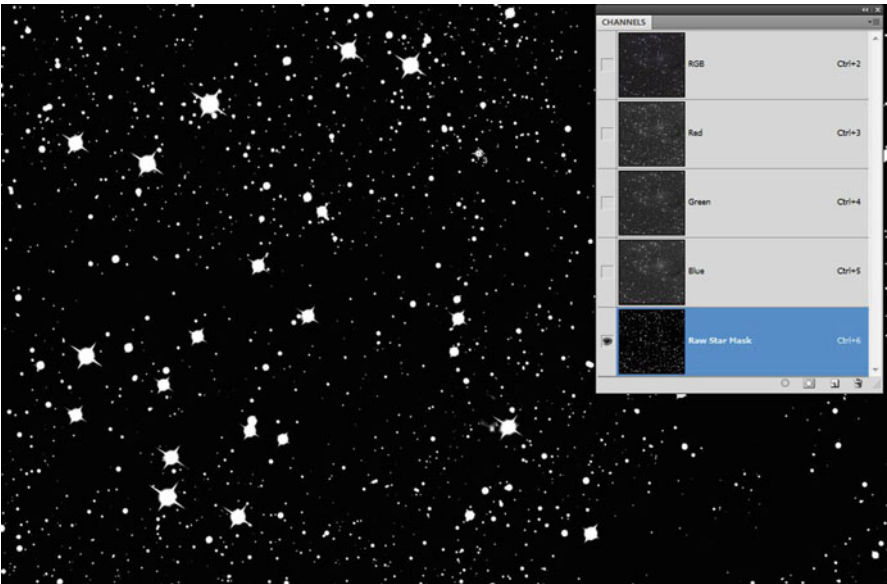


Fig. 12 Alpha channel that contains the mask

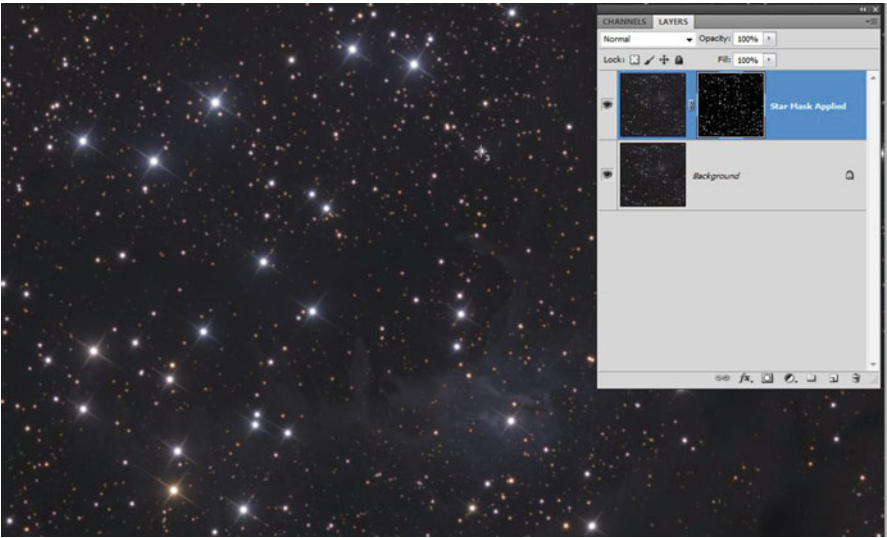
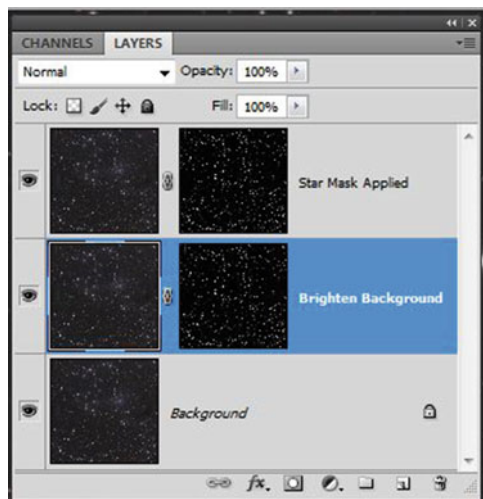


Fig. 13 Star mask as a Hide All layer mask



**Fig. 14** Two layers with star masks

Remember that the way mask works is “White selects – Black protects.” So if we want to select the background, we need to turn it white on the mask with black around the stars. We will use the middle layer to control the background brightness, so we need to invert the middle layer’s mask. For this and other adjustments we will need the Masks Panel. If you don’t see this you may need to turn it on under the Window menu and make sure the Masks option is checked.

Select the Mask on the middle layer, and then on the Masks panel click the Invert button (Fig. 15).

After you have inverted the mask, you want to add a Curves adjustment layer so that it is on top of the Brighten Background layer with the newly inverted mask. You can use the Adjustments window to do this or the Layer Menu – New Adjustment Layer – Curves to accomplish the same thing. Now select the new Curves adjustment layer and go back to the Layer Menu and select Create Clipping Mask (Fig. 16).

Clipping Masks are a very powerful concept that allows adjustment layers to affect only the base layer, which is the layer that now has the layer name underlined. You can tell the adjustment layer is clipped by the indentation of the layer, and the down pointing arrow showing the path the adjustments will take to the base layer.

With the Curves adjustment layer selected, make a small adjustment to bring up the faint background data and stop right at the point where you start to get dark rings around the stars. This is the edge of the mask cutoff that we are seeing. If we refine the mask, we can blend in the hard cutoff with a nice, smooth transition (Fig. 17).



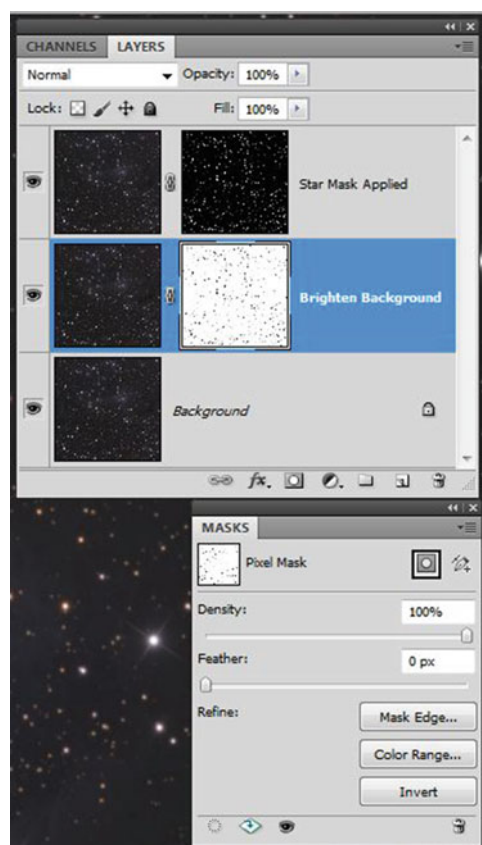


Fig. 15 Inverted star mask

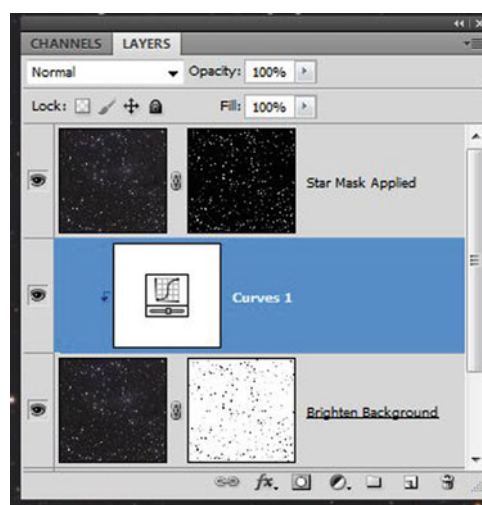
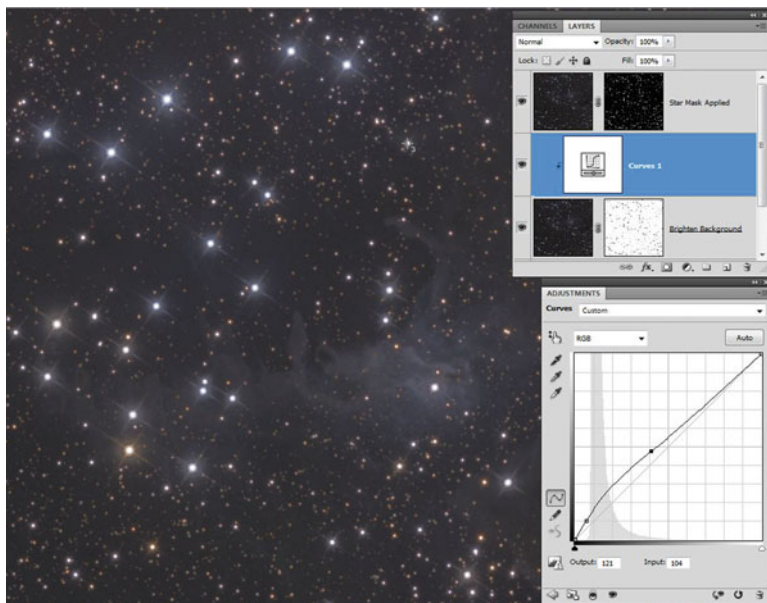


Fig. 16 Curves adjustment layer as a clipping mask



**Fig. 17** Curves adjustment applied through the mask

To do this, select the mask and right click. This will bring up a drop-down menu where you can select Refine Mask for the mask refinement tools. This is the same as using the Mask Edge button on the mask's panel (Fig. 18).

Once the Refine Mask panel is up, we can look at which type of View mode will work best for our needs. First, select the Black and White option to reveal the mask in its true gray scale form. A useful keyboard shortcut is the letter K. You can see that the stars are shown as black with a white background. I repeat an important masking statement, "Black Conceals – White Reveals." Here we are selecting the background and protecting the stars. What we want to do is soften or feather the selection edges to smooth the transition between the black and white cut-off (Fig. 19).

With the mask showing, we will use the power of the Edge Detection controls. These controls were originally developed to help select and composite hair, which is normally very difficult. We will use it to select the star edges and their associated halos. Click the Smart Radius check box then push the radius size up in pixel size to a fairly large radius. In this example I am using a 55 pixel radius (Fig. 20).

Even though the edge detection is working well to select the halos, the transitions still have a very hard cut-off. The Adjust Edge control sliders allow fine adjustments of the edges of the mask. It is useful to add a small amount of smoothing and feathering. If you increase the contrast you will wipe out the selections of the star halo, so we will leave it alone for this mask.

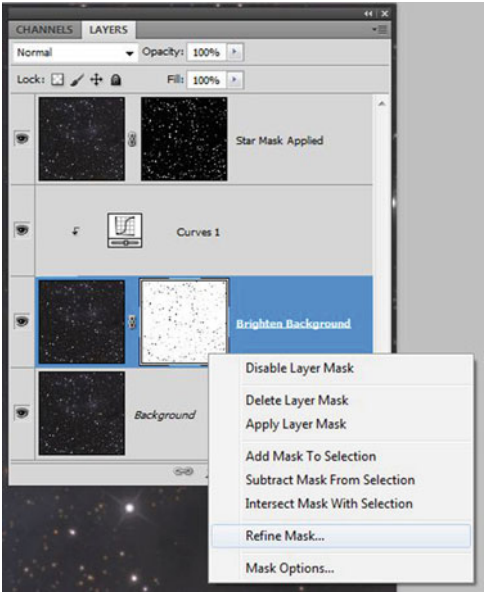


Fig. 18 Select the Refine Mask option

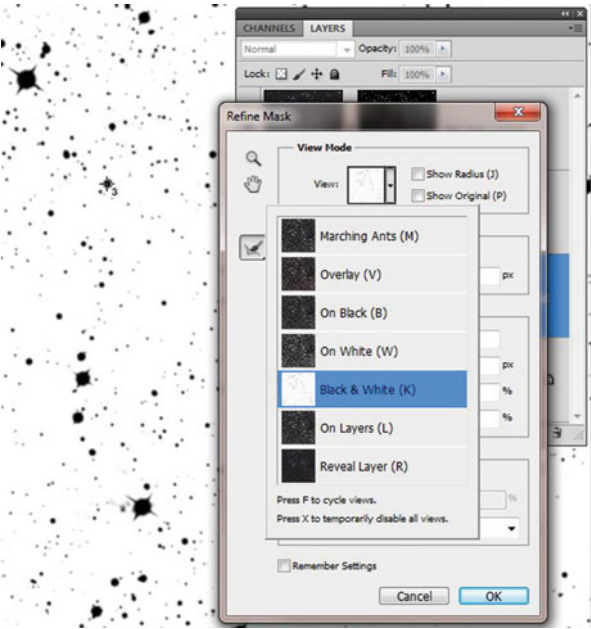
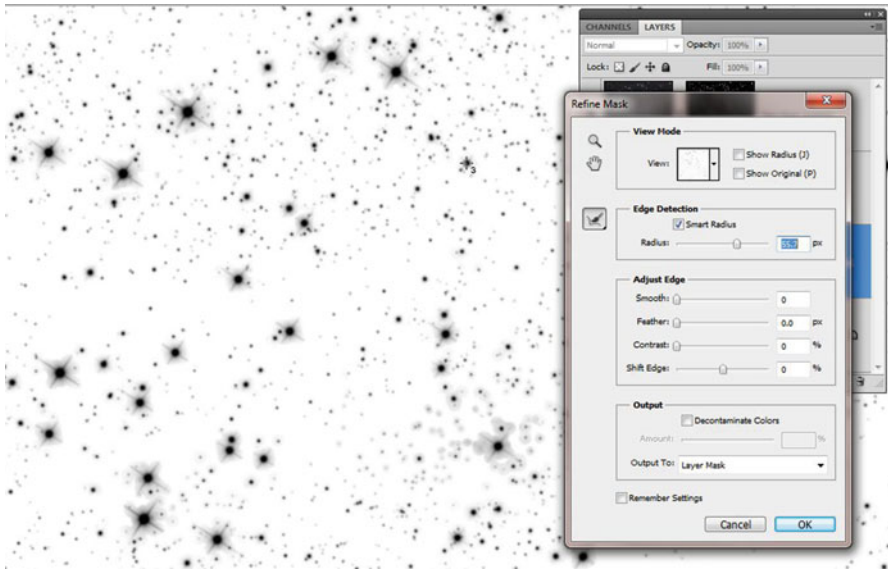


Fig. 19 Black & White (K) reveals the mask



**Fig. 20** Edge detection adjustments

Because this is a “Reveal All” layer mask if we want to expand our reach of the protection, we need to increase the size of the black areas around the stars. To do this we need to shift the edges negatively, which will expand the black. In this case I shifted the edges by  $-30\%$ , and I follow what happens to the mask on the black and white view mode. But it is very useful to see the real time results by pressing the L key, which will switch the view mode to On Layers. I swap the views back and forth using the K and L keys to view the mask and the results at will (Fig. 21).

Once you are happy with your adjustment results, you need to determine how you want to save the changes to the mask. The Output controls allow you to save the changes with several options.

- Selection – this will turn your adjustments into a marching ant selection.
- Layer Mask – this will output your changes to the currently selected layer mask.
- New Layer with Layer Mask – this will create a new layer and layer mask with the adjustments applied. This is my favorite, as it will preserve the original mask.
- New Document and New Document with Layer Mask are not very useful for our purposes here but produce interesting combinations of the mask and picture in a duplicate image (Fig. 22).

Select the New Layer with Layer Mask option and click OK. This will create another layer and layer mask on top of the old layer with all the refinements. This action will also turn off the visibility of the original layer, but it is there for safe keeping (Fig. 23).

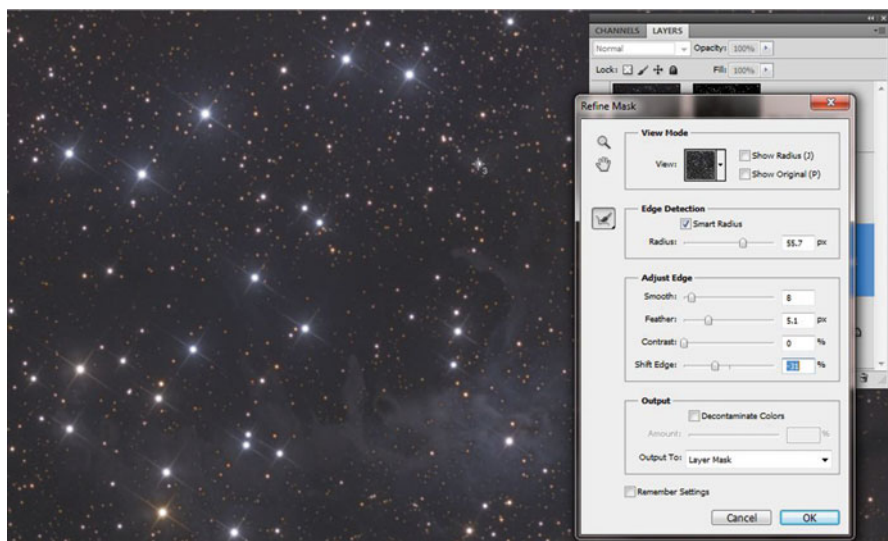


Fig. 21 Adjusting the edges of the mask

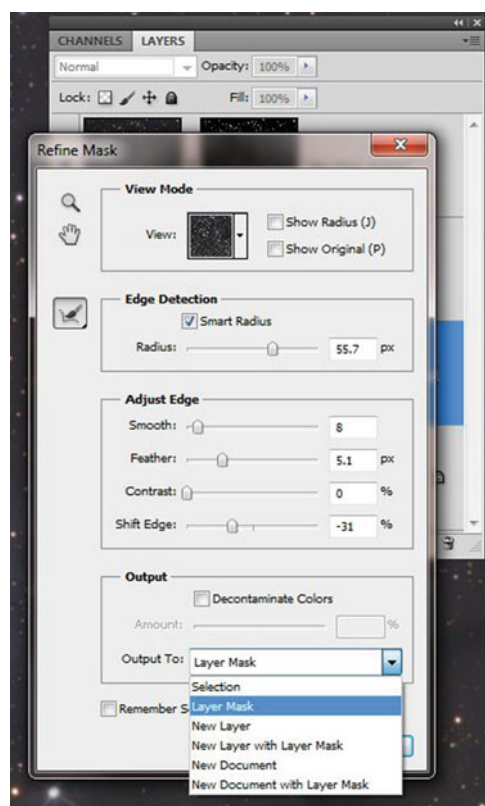
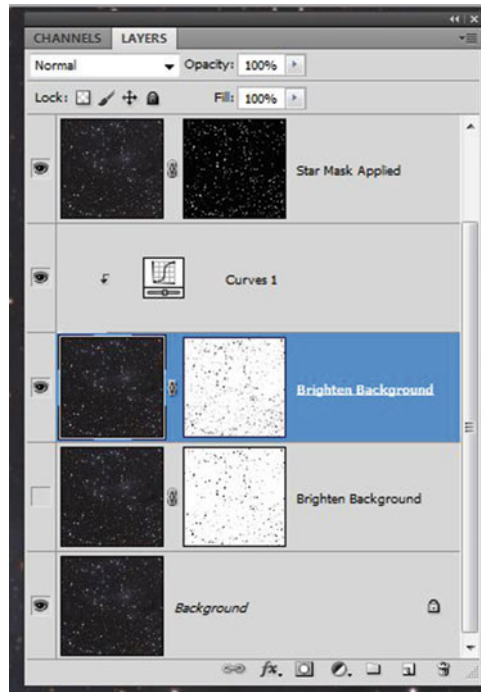


Fig. 22 Output options



**Fig. 23** New layer with the refined layer mask

You can now adjust the layers' opacity to taste and even use the top layer with the 'Hide All' mask to apply adjustments to the stars while protecting the background. Adjustment layers such as Brightness and Contrast can control the star profile and brightness factors while Vibrance can add color and pop to the stars without over saturating the background structures. Using these methods you can selectively control color, contrast, and sharpness with precision targeting (Fig. 24).

Mastering the methods for controlling your High Dynamic Range will give your images more depth and dramatic appeal. The time and effort spent will reward you with the ability to have more control over the final result, allowing you to push your images to new heights.



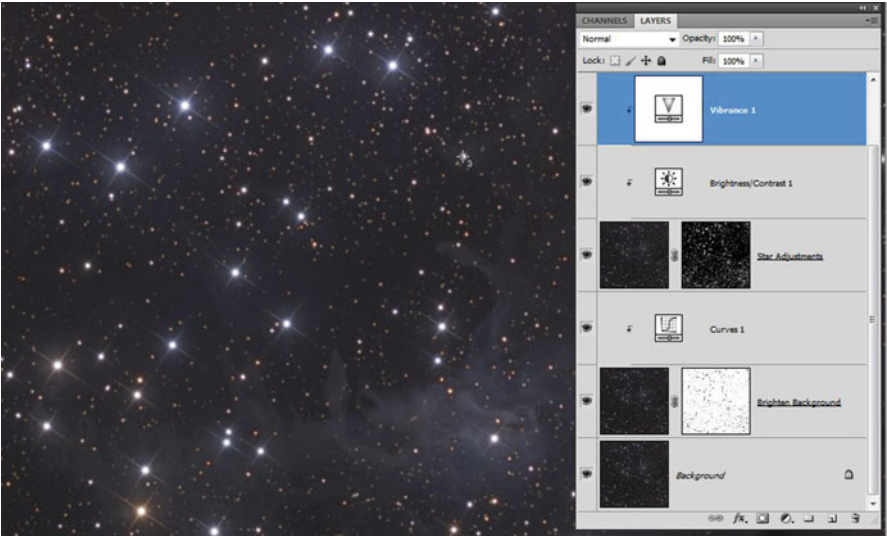


Fig. 24 Star adjustments



Completed image of NGC 225 using the methods described in this chapter



Completed image of IC 5067 using the methods described in this chapter

Lessons from the Masters

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