Photoshop® Basics:
The Standard Curve

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Objective

Bring out the dim details in an image, while preserving bright details effectively.

Techniques
• Set white point
• Set black point
• Linear and non-linear histogram stretching

Tools
• Photoshop® Levels
• Photoshop® Curves

> **Chapters begin with a clear statement of the techniques and tools you will learn to work with.**
>
> **Terms introduced in a chapter are explained in detail in the Definitions section (facing page).**

Description

This chapter covers the heart and soul of image processing for just about any astronomical image. You will learn how to apply the principles of the Zone System using Photoshop® CS (or later). Other image processing programs, such as Picture Window Pro and Paint Shop Pro, include similar tools but the Levels and Curves tools in Photoshop® are powerful and fluid. Photoshop® CS adds a critically important feature: the ability to use layers and other tools with 16-bit images. Since 16-bit images contain up to 256 times as much information as 8-bit images, this is a very important feature for CCD image processing.

The key to success is mastering the somewhat challenging Curves dialog. You will learn the basic shape of a useful curve, as well as how to tweak that basic shape to get specific results. You will also learn how to use Curves to balance the available brightness levels between Zones.

Basic processing involves defining the range of data you want to work with (setting black and white points with Levels), and then expanding the dark areas and compressing the bright areas using Curves. Typically, you will use multiple iterations of Curves to accomplish your goals. You will use Levels several times to keep the black point appropriately controlled.

Definitions

Black point: A Levels slider for setting the darkest value in the image—all darker values will be rendered black. Used to remove the Dark Zone data from the image.

Clipping: Said of a Curve when it reaches the top line of the graph before reaching the right-hand side of the graph. Effectively lowers the white point, which is often undesirable. Clipping is usually avoided by adding additional points to the right of the existing point(s), and reshaping the Curve so it no longer clips.

Curves: A Photoshop® tool for making non-linear adjustments to the image's histogram. You add points to the curve to control which portions of the data are expanded or contracted. Expansion means that more of the available brightness levels are used for the data; contraction means that fewer brightness levels are used. When more brightness levels are allocated to a region, contrast is commonly said to be "stretched" (expanded is a more accurate term, however) in that region. Since there are a fixed number of brightness levels, if you stretch in one region, then you must contract in another. Typically, you expand in the dim areas, and contract in the brighter areas.

Gamma: A slider in the Levels tool that adjusts brightness and contrast simultaneously using a midpoint adjustment. Moving the slider to the left moves the midpoint to a dimmer portion of the image, allocating more brightness levels for the dim portions of the image, which brightens the image overall. See Curves—in a sense, Gamma is a simplified Curve tool.

Grayscale: A palette consisting only of gray values (no color). When you load a FITS image into Photoshop®, it is automatically assigned a Mode of Grayscale.

Histogram: A graph that shows the relative number of pixels at each brightness value. The greater the number of pixels at a given brightness level, the higher the peak. Linear and non-linear changes affect the histogram. You can use the histogram to evaluate how effectively Levels and Curves are modifying the data.

Levels: A Photoshop® tool for making linear adjustments to the image's histogram. See Curves for comparison. Levels is used to adjust the White Point and Black Point (and occasionally the Midpoint is moved for Gamma adjustments).

Linear: Brightness and Contrast adjustments that preserve the internal brightness relationships of the image. Nothing is expanded or contracted. Linear changes are typically limited to changing the White Point and Black Point.

Midpoint: Used to adjust image Gamma. See Gamma.

Non-linear: Brightness and Contrast adjustments that do not preserve internal brightness relationships. One part of the image may get a large boost, while another part may get only a small boost, or even a cut, in brightness and/or contrast.

Points: Added to the Curves dialog to control how much boost or cut each brightness range in the image receives.

White point: A Levels slider for setting the brightest value in the image—all brighter values will be rendered white. Lower the white point when there is no data in the brightest values.

Photoshop® Tips

The Levels and Curves dialogs are mainstays of Photoshop® processing. Both are found on the *Image » Adjustments* sub-menu.

Levels

The Levels dialog [...] three sliders below the histogram that allow you to set the image's black point, midpoint, and white point.

Black point: The darkest brightness level in the image. All pixels darker than the black point will be rendered as black.

White point: The brightest level. All pixels brighter than the white point will be rendered as white.

Midpoint: Divides the image into two zones. The left side will be rendered with one half of the available levels, and the right side will be rendered with the other half. For example, if you move the midpoint slider to the left, the image will brighten because the darker values now occupy more than half of the available brightness levels.

The black point and white point settings are used often, but the midpoint setting is used infrequently. Curves is a more powerful way of solving the same types of problems. Use the midpoint slider for minor adjustments to make an image a little brighter or a little darker.

The midpoint slider adjusts image gamma. Gamma controls the brightness and contrast of an image simulta-neously. Gamma is not as powerful as Curves; it is a simpler approach to adjusting the image histogram.

NOTE: The brightness of your monitor controls how dark or bright your images appear. For best results, perform a monitor calibration using the tools provided with Photoshop®. You can use a third party tool such as Pantone's Spyder series of calibration tools. Or you can purchase a monitor that comes with its own calibration hardware, such as the Sony Artisan.

❧ TIP: The Levels dialog contains 256 brightness levels. Your CCD images typically have 65,536 brightness levels. This means that you must work at a lower resolution in the Levels dialog (and in Curves). That is why you repeat Levels and Curves multiple times: to increase the precision of your adjustments.

> **Photoshop tools are introduced with full details about their use.**
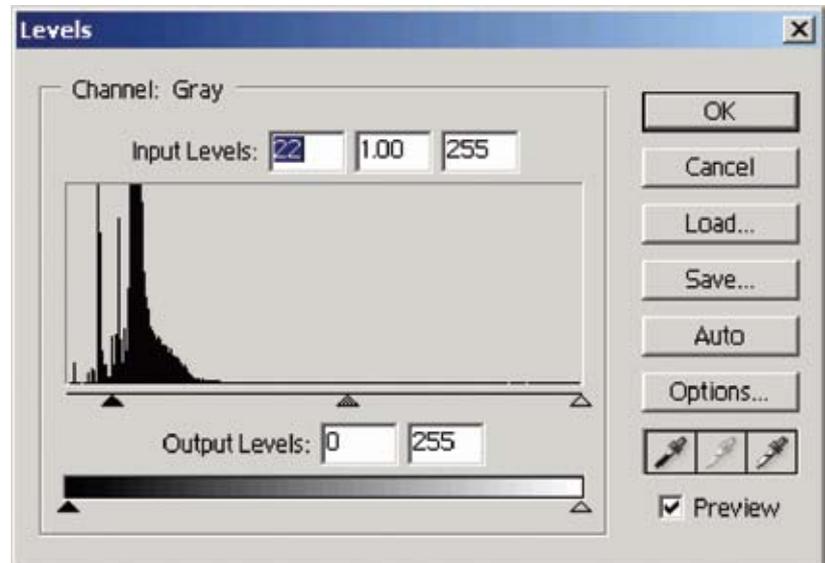
Curves

The Curves dialog is one of the richest, and most complex, areas of Photoshop®. This complexity gives you a lot of processing power, however, so the Curves dialog is worth some close study. You'll see many examples of different things you can do with Curves throughout the book.

The example at right shows a typical shape for a curve used with astronomical images. I call this the Standard Curve. You will find that you can use a curve like this for generalized brightening of your image, which will get it to the point where you can start to use the more advanced Zone System techniques. The important thing to note here is that you can have more than one point on a curve, and that Photoshop® automatically fits the curve to the points that you add.

The points correspond roughly to the zones in the image—that's what makes it a Standard Curve. Working from bottom left toward upper right, the four zones occupy the spaces between the points. Note that the first point is in the bottom left corner; it represents zero brightness and is the start of the Dark Zone. The next point (up and to the right) is approximately on the boundary between the Dark and Dim Zones.

❧ Tip: You might wonder how I can say that these points correspond (approximately!) to the zones when the zones are relative. The answer is simple: this is only true if the black point has been correctly adjusted. Using Levels, always move the black point just to the left of the histogram peak.

Note: There are grayscale bars at left and bottom of the graph. If the darker portion of the bars is not at lower left,

click the double-headed arrow in the middle of the lower grayscale bar to flip the bars.

❧ Tip: Click and drag the cursor in the image to see where on the curve a given brightness level lives.

❧ Tip: To add a point on the curve that precisely matches a brightness level in the image, hold down the Control key and click in the image.

❧ Tip: You can edit the numeric values of a point by changing the values in the Input and Output text boxes. To move to a point so you can edit it, use the Control + Tab keys.
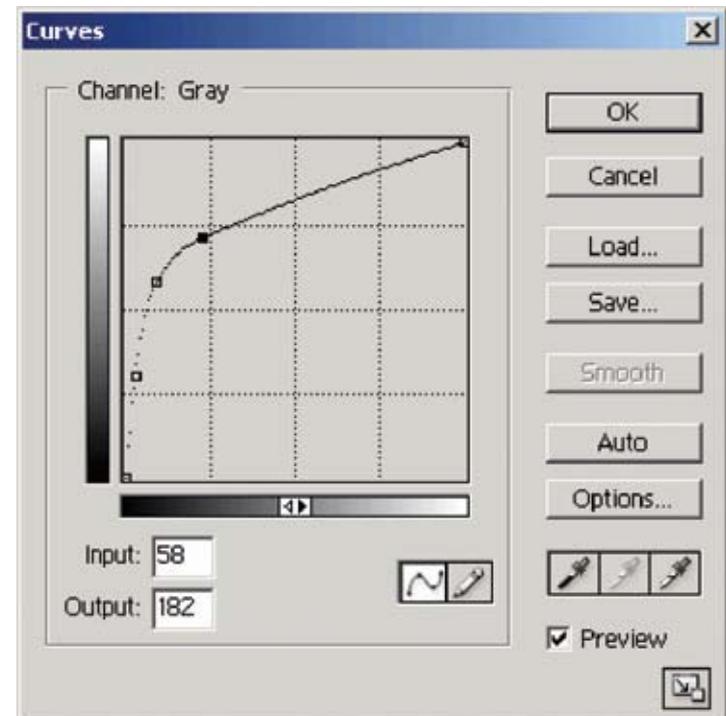
Open a File

When you open a CCD image file in Photoshop, you often will not see much detail in the image. The brightest stars might be visible as shown here, or you might not see anything at all. This is normal! Most CCD images have 65,536 brightness levels, and only a small percentage of them are bright enough to be visible.

The easiest way to work with your CCD files in Photoshop is to use a FITS plug-in. (Most CCD files are stored in FITS format.)
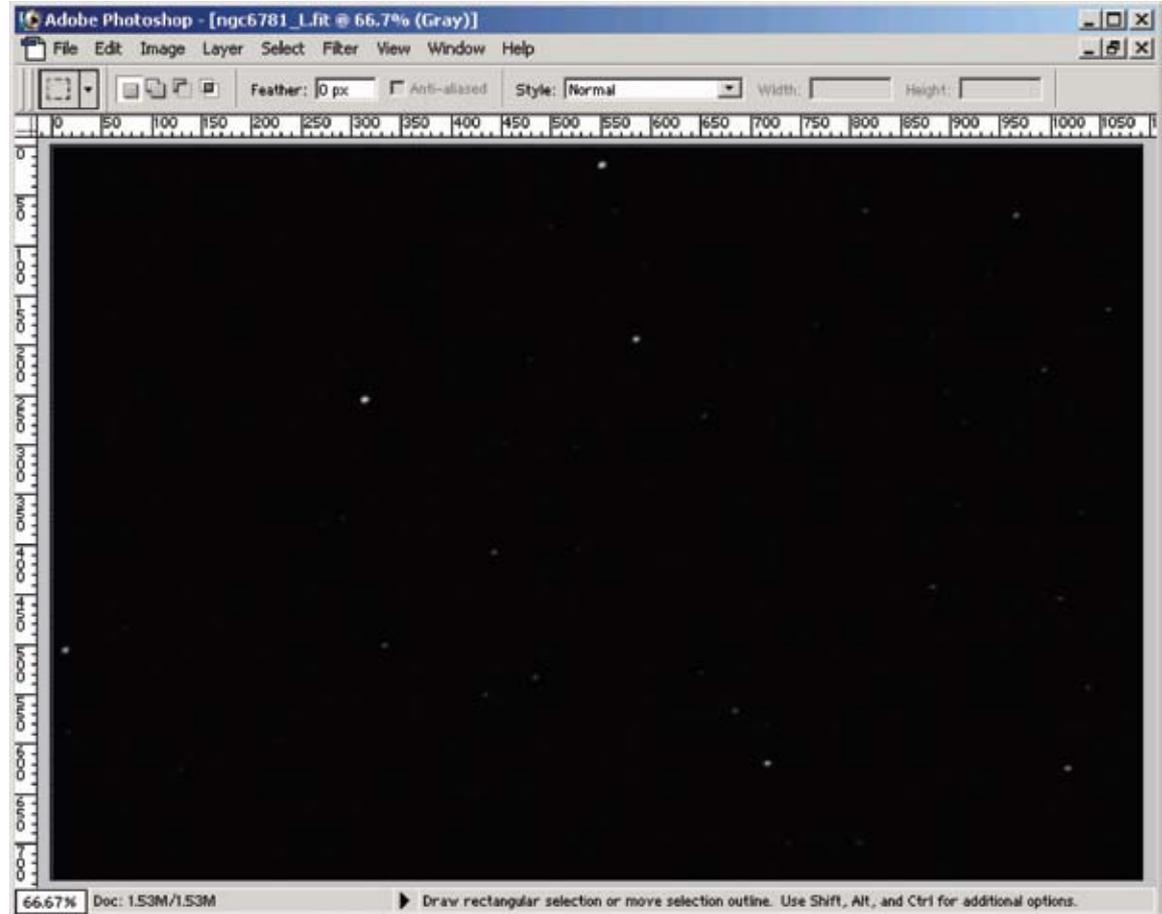
There are free versions of FITS plug-ins available, as well as pay versions with specific features you might find helpful. The two most commonly used are the FITS _____ 'S Liberator from NASA _____

http://_____

http://hubblesource.stsci.edu/sources/toolbox/entry/fits_liberator/

Tutorials are based on files on the free DVD.

If you would like to follow along with this exercise, open the following file from the DVD in Photoshop® CS (or later):

\C2\m74_final.fit

Set the Black Point and White Point

To access the Levels dialog, use the *Image»Adjustments» Levels* menu item

The Levels dialog displays the image's histogram, a graph of the brightness values in an image. The histograms at right are more or less typical for astronomical images.

The left side of the histogram maps darker values, and the right side maps brighter values. Both histograms tell us that there are a large number of darker values (the peaks at far left), and very few bright values—there is just a dribble of values in the rest of the image in both examples.

The dribble of bright values completely runs out toward the right side of the histogram at top right. This means that there are no values brighter than where the thin black line stops. The white point needs to be set at this juncture, as shown at top right. Click and drag the open triangle (slider) until it is under the point where the data runs out.

In the bottom right example, there is open space to the left of the data peak. This means the black point needs to be raised. Move the black point slider just to the left of the start of the data peak, as shown. No adjustment to the white point is required for this file.

NOTE: Make the adjustment at lower right if you are following along with the exercise in Photoshop CS.

**Tutorials include all menu references, sample dialogs, and useful tips.**
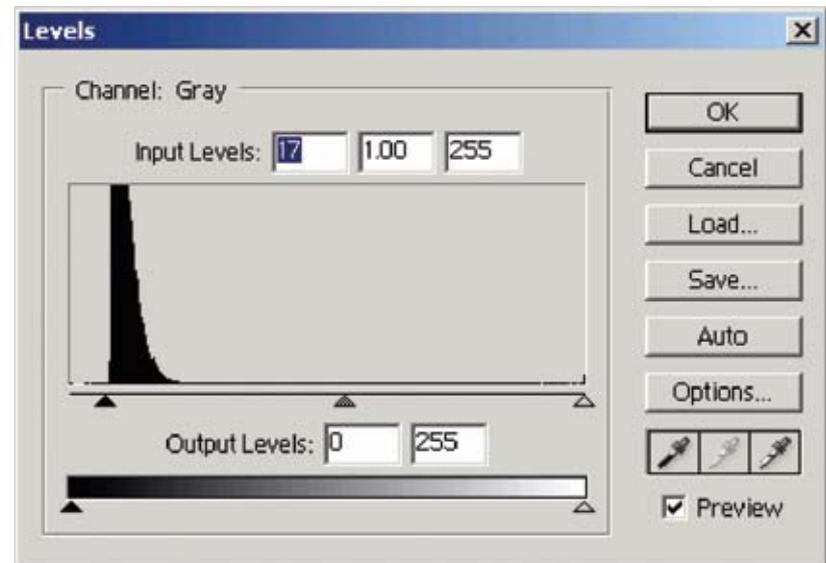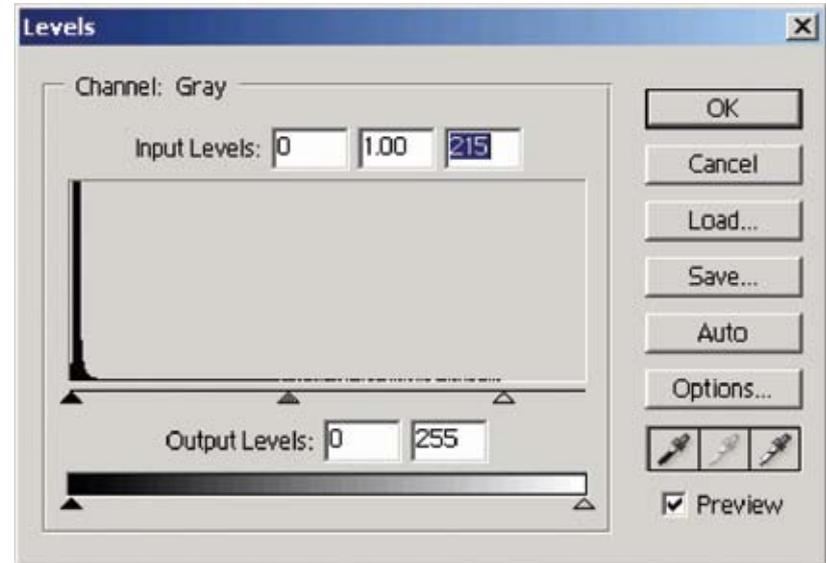
Curves Dialog

To access the Curves dialog, use the *Image»Adjustments »Curves* menu item.

The Curves dialog looks innocent at first glance. It's only when you use it that you realize how complex it is. Given that the Curves dialog is the single most powerful (and thus most commonly used) tool for astro imagers, a road map will help you find your way.

❧ TIP: Make sure that the grayscale bars at left and bottom of the Curves dialog are oriented as shown. If necessary, click the double-headed arrow located at the middle of the bottom grayscale bar to flip the orientation of the bars.

The diagonal line on the Curves graph is the heart and soul of this tool. The diagonal line represents zero change, and is always the starting condition. Your job is to turn that line into an appropriate curve, so I will call it a curve from now on—even when it is a straight line.
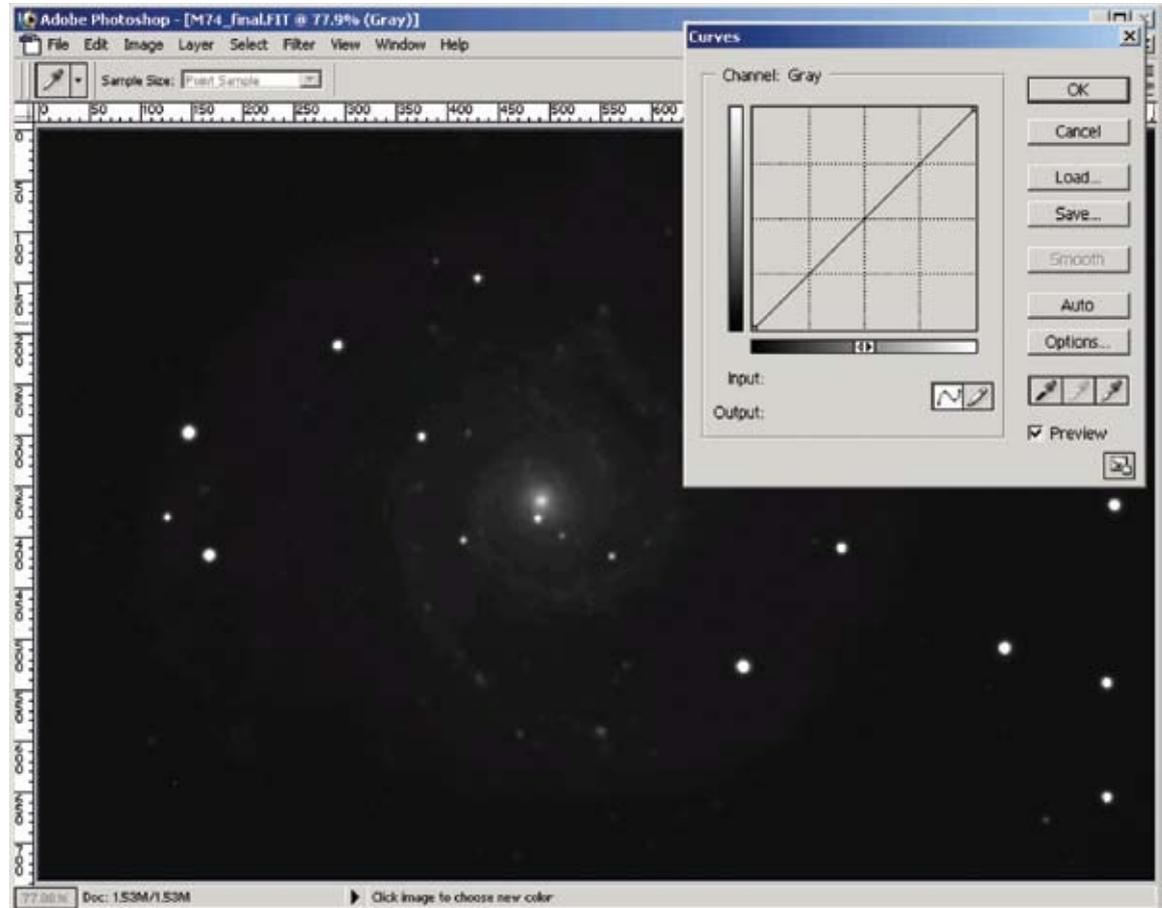
There are already two points on the curve: one at bottom left, and one at top right. These are the default points that define the curve. They correspond to the black and white points.

To make changes to the image, click on the curve to add one or more points, and then drag the point to reshape the curve.

Add a Point

The left side of the Curves graph controls the dim portions of the image, and the right side controls the bright portions. As you learn the Zone System, you can place points on the curve corresponding closely to the positions of the various zones—even sub-zones.

Click on the curve to add points. Click and drag to reposition a point. Photoshop adjusts the curve to include the new location of the point. Dragging up, as shown here, brightens the corresponding portion of the image. Dragging down darkens, and is seldom used.

In this example, the added point is on the left half of the Curves graph, so the dim portions of the image are brightened. The curve adjusts to the added point, so bright portions of the image are also affected (You'll learn how to prevent unwanted changes to the bright portion of the image shortly. This is accomplished by adding additional points to the Curves graph.)
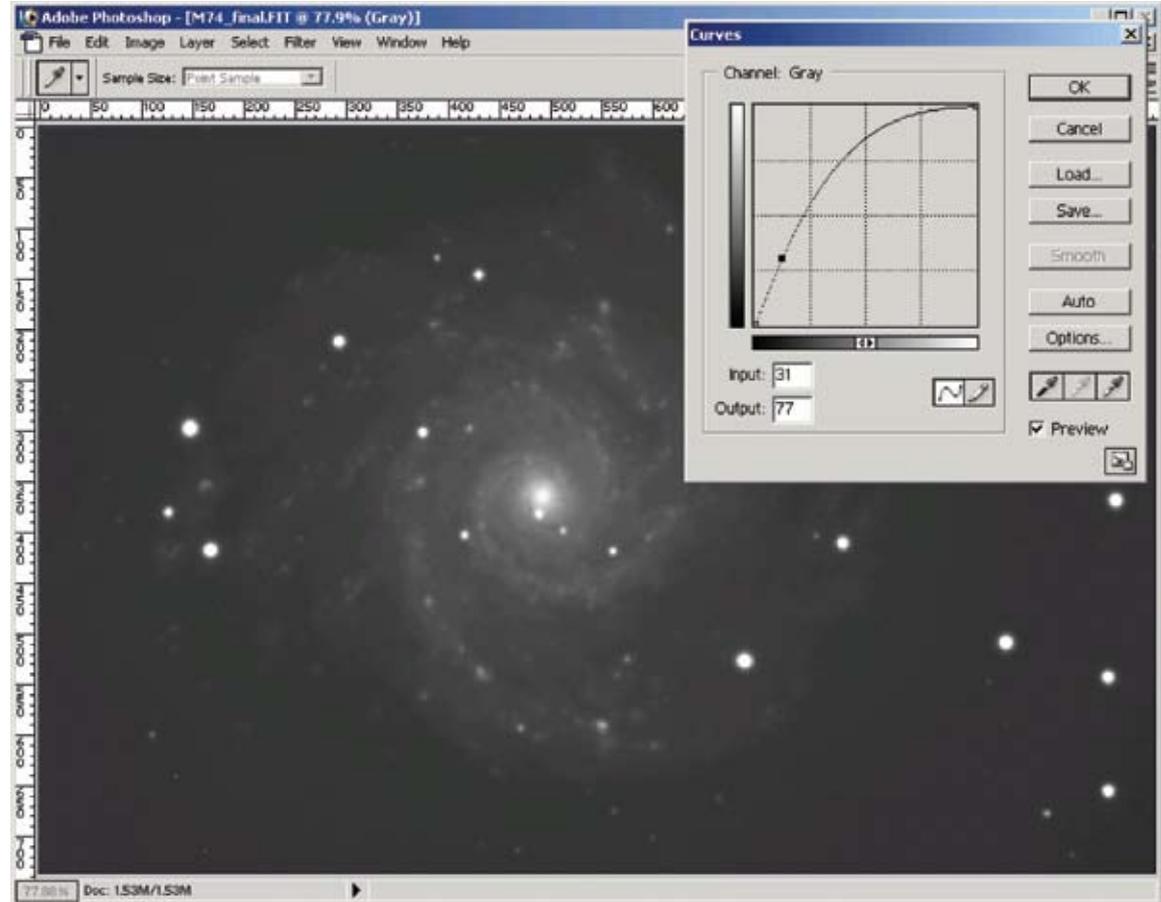
❧ Tip: Increasing the brightness of dim areas often makes the background brighter. Always use Levels to compensate by refining the position of the black point. It's almost always necessary to make Levels adjustments after changes to Curves.

A Curve too Far

A Curve that is too aggressive can lead to an image that has a Dim Zone that is *too* bright. However, the more experience you get with the Zone System, the more you will be able to control and work with aggressive curves.

The image at right has a very aggressive curve applied to it. The core of the galaxy is not washed out (thanks to that flat-to-the-finish in the Bright Zone), but it is so bright that it will be challenging to emphasize details in the core. In technical terms, the contrast is compressed in the Bright Zone, leaving little room for emphasizing details. In simplest terms, there are too few brightness levels dedicated to the Bright Zone.

All of the zones need to be balanced with each other so they each have enough brightness levels available. If you over-expand the Dim Zone, the other zones will be [obscured]
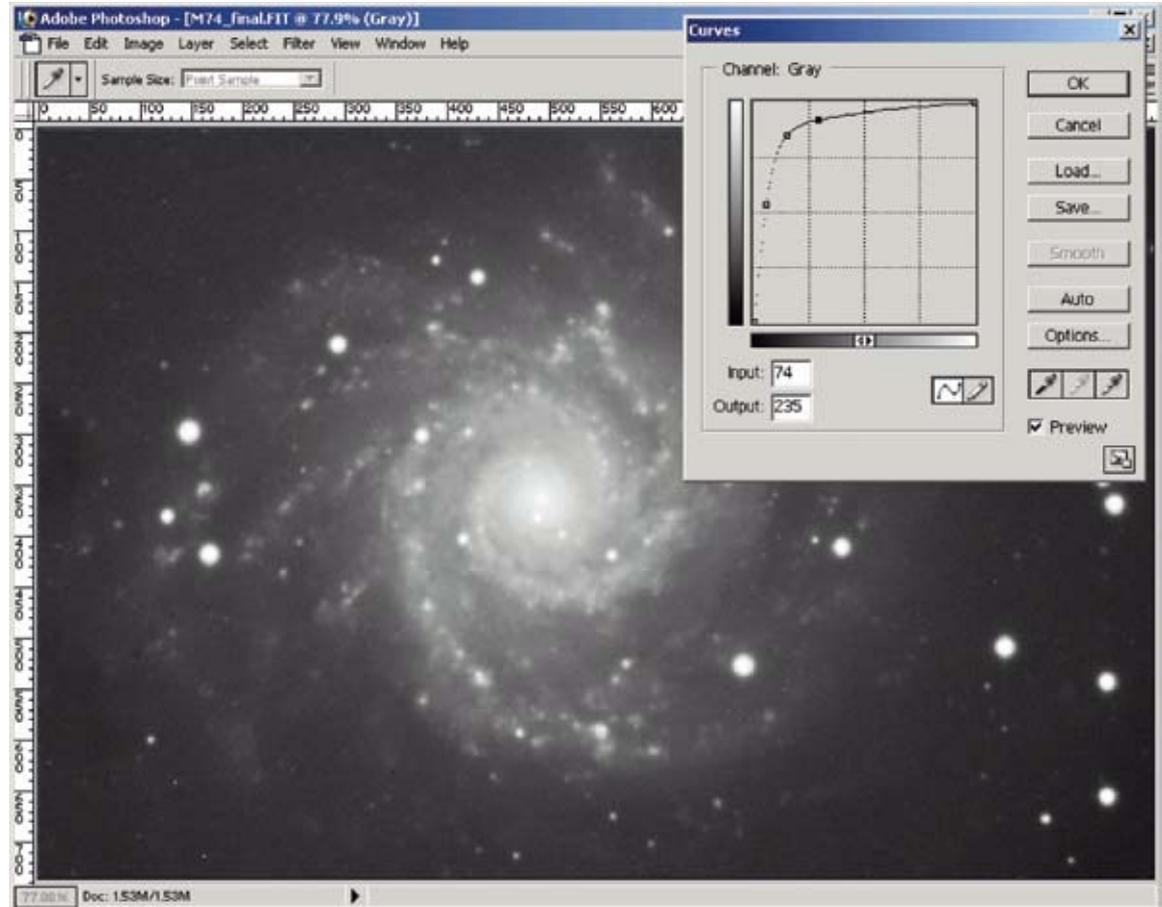
and you won't see details in the other zones. If the Bright Zone isn't compressed sufficiently, you won't be able to reveal enough detail in the Dim Zone. This is not so much about technique as it is about a new way of thinking about the image and its processing. That is why we take time to balance [obscured] using the Zone System.

**Tutorials also include examples of what *not* to do.**

Background Control: Levels

Each time you make a change with Curves, you are brightening the dim areas of the image. Even if you imaged under very dark skies, this is also going to brighten the image background. To avoid wasting your histogram changes on the image background, check the black point in Levels after each application of Curves. Raise the black point as needed (see figure at right for an example).

Note that the black point is always raised to a position just to the left of the steep rise in the histogram plot. There is a small tail visible in this example. Such tails can be minor, as here, or quite large. They usually indicate a gradient in the image, but nebulosity or extended areas of nebulosity of dim areas of galaxies can also cause such tails. If raising the black point above the tail removes data from the image, then you should leave the black point below the tail. If raising the black point beyond the tail only removes background, then you are dealing with a gradient. You might be able to clean up the gradient just by putting the black point above the tail, but if not, consider Russell Croman's Gradient XTerminator software:

http://www.rc-astro.com

As you work on the image with multiple iterations of Curves, the histogram changes. The left side of the histogram expands, and the right side of the histogram shrinks (compresses). This reflects what is happening in the image. The dim areas occupy more and more of the available bright areas, and the bright areas occupy fewer and

The Relationships between tools are illustrated and explained.
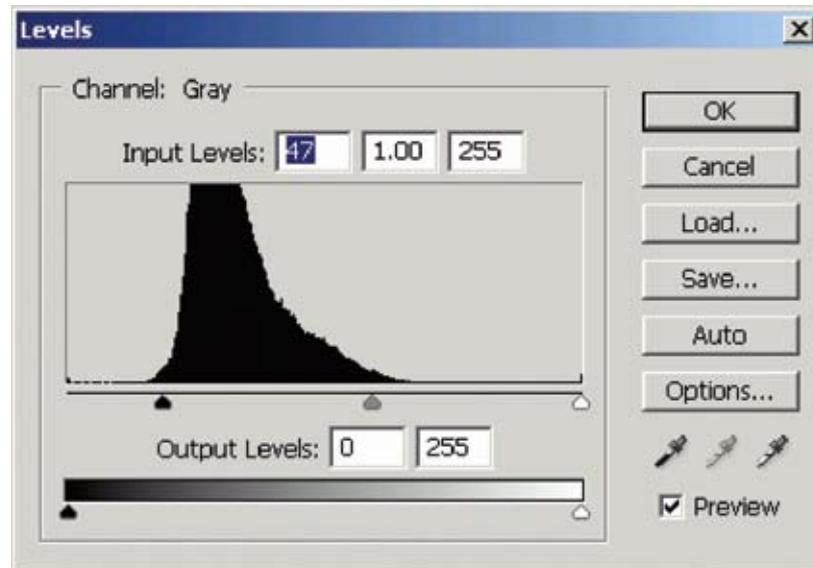
Photoshop CS includes a Histogram palette. This is a small version of the histogram (see below). You can't make changes with the histogram palette; use the Levels tool. The palette is a handy way to watch the histogram as you work with tools. The Histogram palette uses a fast calculation, so it might differ somewhat from the "official" histogram in Levels.

NOTE: Even extremely dark skies have background brightness at some level. The atoms in the air glow in red, for example, and the dust in the solar system also contributes some brightness. Every image will have some need of background control.