Text and photography by TONY PUERZER

IMAGE-STACKING BASICS

Combining multiple frames into a single photo is the secret to noise-free astro-images

WELL-EXPOSED, detail-rich astrophotos are a joy to behold. Such images have creamy-smooth tonal transitions and respond well to postprocessing. However, achieving these results can be difficult if you're working from a single frame. The main enemy is noise generated by the camera's light-sensitive detector and internal electronics.

The root of the problem is that many targets we're trying to capture are so faint, they struggle to rise above a DSLR's noise floor. One obvious solution is longer exposure times to record more of the desired "signal." Unfortunately, this isn't always practical. If, for example, you're using a fixed tripod and wish to avoid star trails, exposures generally can't exceed 30 seconds, even with a wide-angle lens. And there are also limits for longer exposures made on a tracking mount. What about cranking up your camera's ISO setting instead? It's an option, but one that has the undesirable effect of increasing the visibility of digital noise.

If you dream of decorating your home with poster-sized prints of your astronomical artwork, pictures that look rougher than 80-grit sandpaper aren't going to cut it. And noisy images aren't just unattractive, they also don't stand up to even modest postprocessing and editing.

Fortunately, there's a simple way to obtain great results with short exposures shot at high ISO settings. It's called *image stacking*.

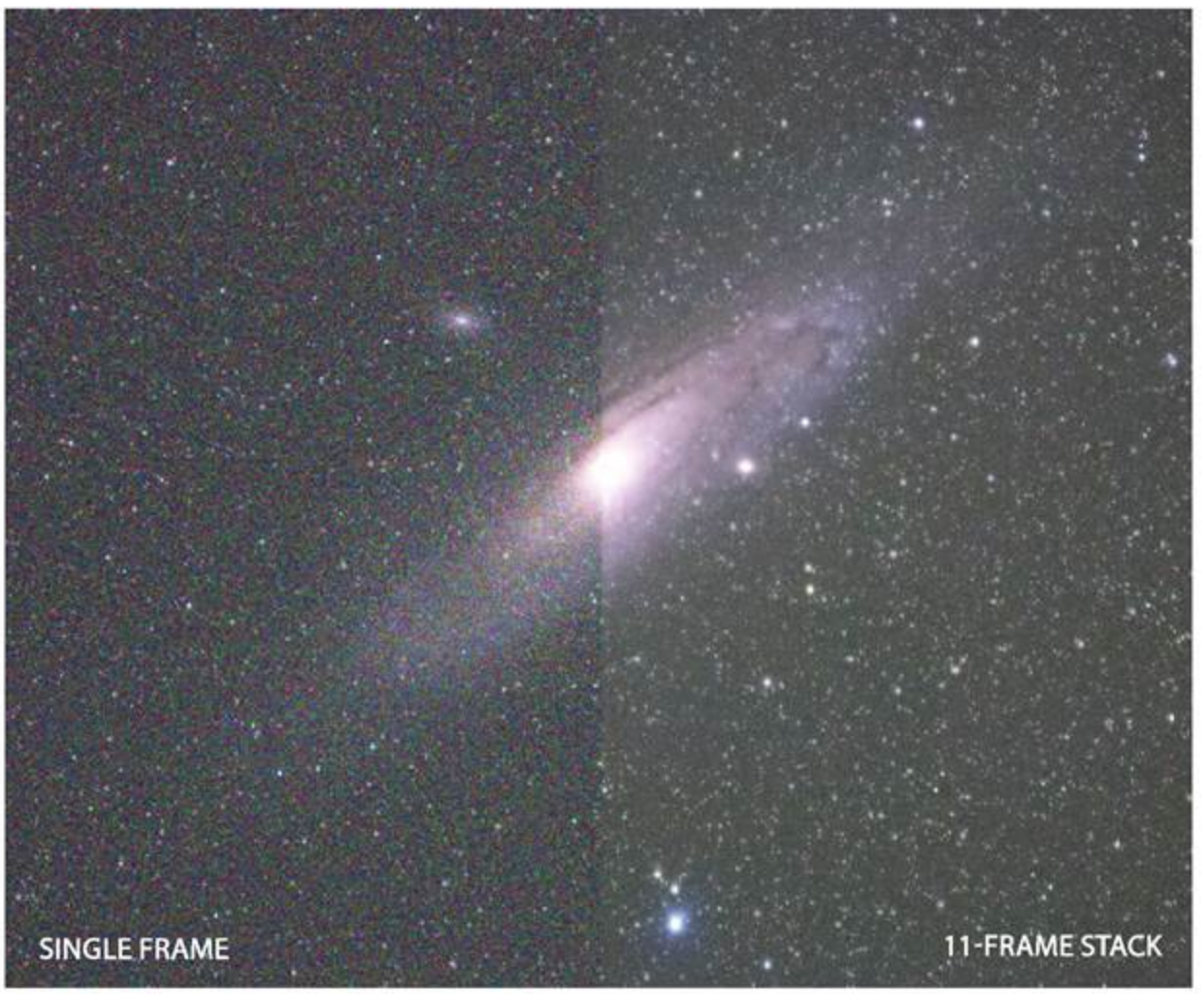
IT ALL ADDS UP

Essentially, the procedure is to capture multiple shots of the same subject, then blend them together during postprocessing. Image stacking succeeds because the "signal" (light from the galaxies, nebulas and stars you want to record) is left untouched, while random "noise" (a confetti-like background) is averaged out. Think of image stacking as a form of astrophotographic noise reduction. The improvement is often quite dramatic.

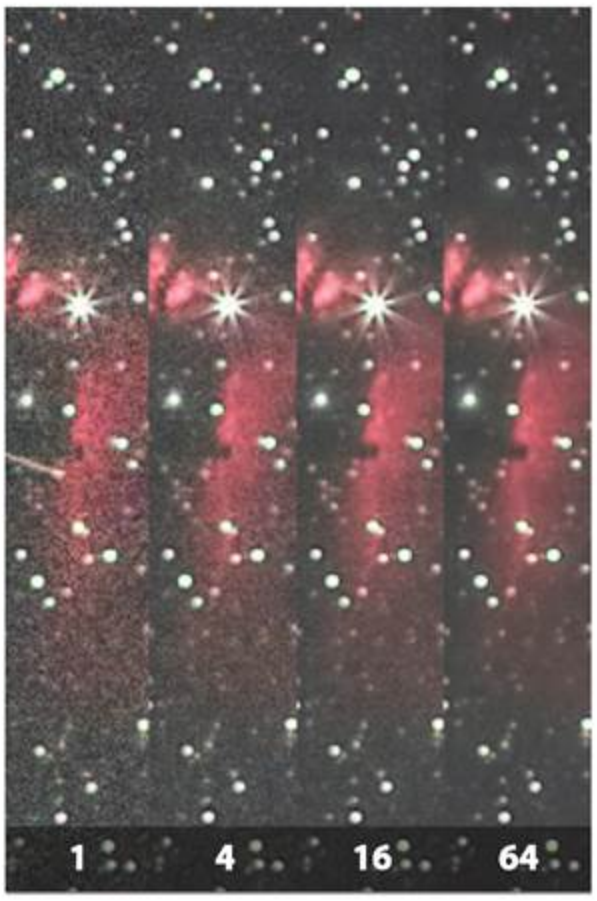
To see image stacking in action, look at the series of images on the next page that are cropped from a wide-field portrait of Orion. The leftmost panel is a single 30-second exposure displaying a fair amount of digital noise. Moving to the right, each subsequent frame shows what happens when 4, 16 and, finally, 64 images are stacked together. Impressive, right?

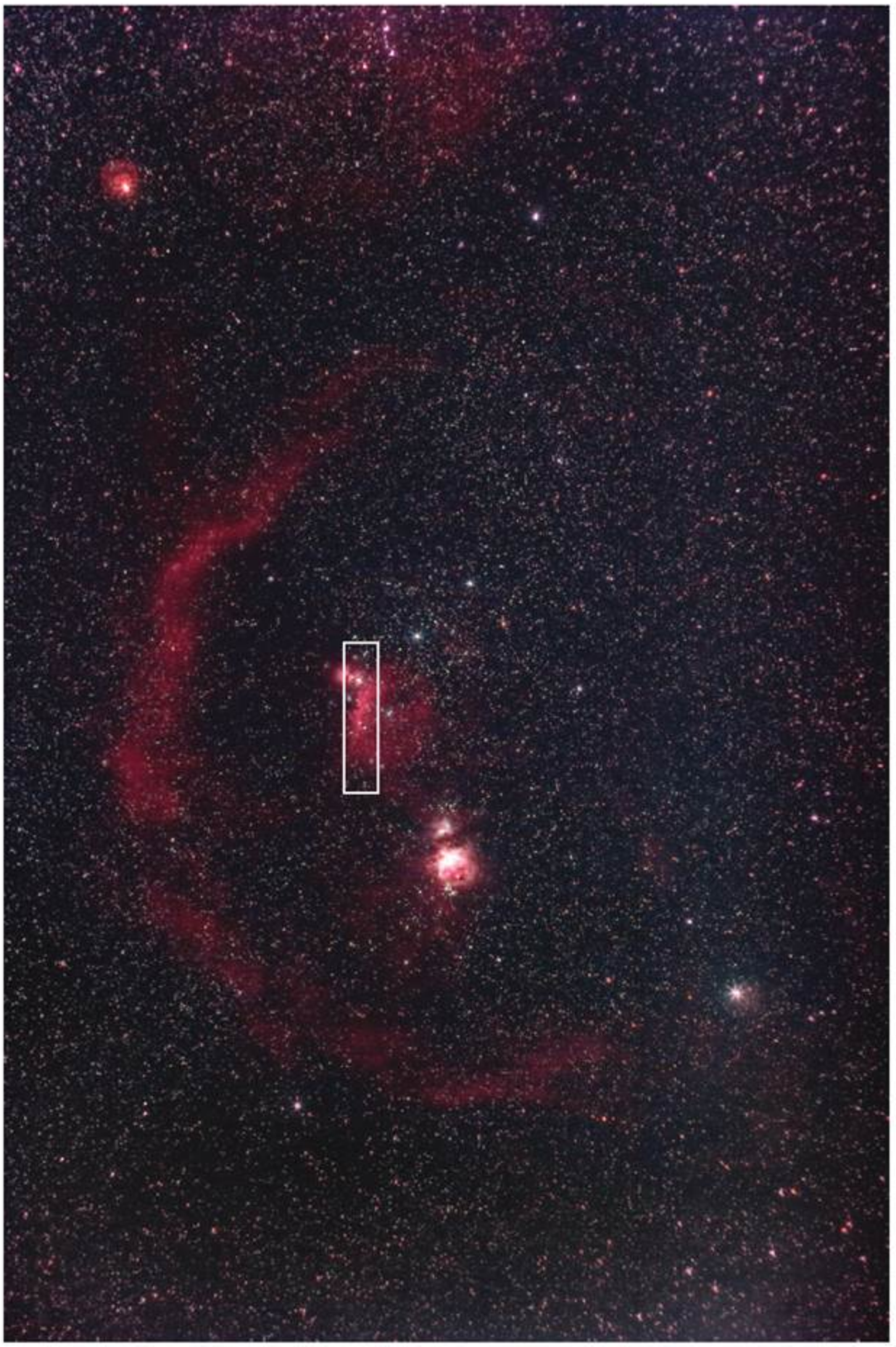
In theory, there's no limit to the number of exposures that can be combined, but eventually, we reach a point of diminishing returns. Each incremental improvement in noise reduction requires *double* the number of shots. So going from four to eight exposures, for example, will provide a distinct improvement, but you'll need to double it again—for a total of 16 images—to get an additional equivalent bump in quality. Want an even smoother background? Now you're talking 32 or 64 frames. Most agree that there's little to be gained by stacking more than this.

Regardless of the number of images you



STACKING THE DECK This split-screen portrait of the Andromeda Galaxy illustrates the benefit of image stacking. Notice how the right side of the image exhibits very little noise and, consequently, features subtle tonal gradations in the galaxy compared with the single frame on the left side. All the individual, unprocessed 30-second exposures used in this comparison were shot at ISO 16,000 with a Canon EOS 80D DSLR camera and a Canon 300mm f/4 lens riding on an iOptron SkyTracker mount. Facing page: The splendid Lagoon and Trifid Nebulas, M8 and M20 in Sagittarius, were imaged last summer during the Mount Kobau Star Party, in British Columbia. The stack of six 300-second exposures was captured at ISO 1600 using a modified Canon EOS 60D DSLR and a Canon 300mm f/4 lens fitted with an Astronomik CLS filter. Digitally combining a series of exposures yields buttery smooth tonal transitions that lend themselves to considerable additional processing.





ORION TEST STRIP Each test strip above is a tiny portion from an image of the constellation Orion, at right. This clearly illustrates how increasing the number of stacked frames further reduces digital noise, even when a moderate ISO 800 setting is used. (The number of frames stacked in the test strips is indicated.) The 30-second tracked exposures were made with a modified Canon EOS 60D DSLR camera and a Canon 50mm lens set to f/2.

plan to stack, it pays to start with the most noise-free frames you're able to produce. Some cameras are better than others in this regard, but even the time of night or the season of the year comes into play. Not surprisingly, the test strips of Orion shown above were captured during the winter on an evening when the temperature was near freezing. The chilly air helped keep the camera's sensor cool, which, in turn, resulted in images that were relatively free from noise. In summer, your best bet is to wait until well after nightfall or, better yet, shoot during the predawn hours, when the ambient air is typically coolest.

CAPTURING PHOTONS

To begin taking individual images for stacking, set your camera to RAW mode and use a Manual exposure setting. It's critical to hold the exposure and ISO settings constant, since the random noise is the only thing we're trying to eliminate. If this is your first attempt, record at least a dozen shots of the same target. This should give you a reasonable set of photos for experimentation. You can even capture images over several nights, assuming the sky conditions and framing remain constant.

You may ask: "Why go to the bother of shooting so many frames? Can't I simply use my computer to make multiple copies of a single image?" Sadly, this won't work. Stacking relies on the fact that image noise is randomly distributed across *each individual frame*—something that wouldn't be true with multiples of a single image.

After you've downloaded your night's work into your computer, review each frame at 100 percent magnification and weed out those suffering from tracking errors or from passing aircraft, clouds or satellites. Although the software's averaging routine will eliminate or minimize some of these intruders, it's always best to start with a set of clean images. Also, resist the urge to perform any image editing at this point—save your processing for the final stacked image.

LET THE MAGIC BEGIN

Frames can be stacked digitally by using one of a number of different software programs, including Affinity Photo, DeepSkyStacker, Nebulosity and Sequator. Some of these will automatically align and stack all your frames. I'm most familiar with Adobe

GLOBULAR GLORY This image of M13 is a stack of just five individual photos, demonstrating that even a few extra frames can make a big difference in reducing digital noise. The 5-minute exposures at ISO 1600 were acquired using a Celestron C6 Schmidt-Cassegrain telescope and a modified Canon EOS 60D DSLR camera.

Photoshop CC, so I'll use that for my workflow example.

In Photoshop, click *File* > *Scripts* > *Load Files Into Stack*, then click *Browse* and select the images you want. Enable both the *Attempt to Automatically Align Source Images* and the *Create Smart Object After Loading Layers* check boxes.

The alignment option is important, even if you used a tracking mount, because each layer must be perfectly aligned with all the rest. (Sometimes, Photoshop fails to automatically align the images. If it does fail, your only option is to manually align all the layers—a tedious operation—or to try one of the other software packages.)

Once the layers are aligned and converted to a Smart Object in Photoshop, click *Layer* > *Smart Objects* > *Stack Mode* > *Median*. I choose "Median" rather than simply "Mean" because it discards "outlier" pixels on individual images (such as those from satellite trails), rather than averaging them into the final mix.

Don't be surprised if all this number crunching seriously taxes your computer's processing power. Depending on the number of frames you're stacking, it's not uncommon for each step to take several minutes—or a few hours. Instead of staring at your computer monitor while this is going on, hit Enter and walk away for a cup of tea.

After the computer has completed its work, the digital noise should be greatly reduced. You'll notice the extent of the improvement by comparing the stacked results with individual frames at 100 percent magnification. If you're happy with what you see, select *Layer* > *Flatten Image* before saving the file and exiting Photoshop.

I prefer to do most of my final tweaking using Adobe Lightroom rather than Photoshop (for my basic technique, see the January/February issue, page 18). No matter what program you employ, I'm sure you'll find your stacked results much easier to manipulate. They'll also withstand a lot of adjustment before starting to break down.

Although image stacking requires extra time and effort during capture, I believe the results more than justify it. Indeed, this may be the only case in which doing the same thing over and over again really does yield better results! ✦

Tony Puerzer is a full-time professional photographer and part-time amateur astronomer living in Nanaimo, British Columbia.