Astrophotography: part three

Piggyback astroimaging

Let a telescope take your camera for a ride and capture amazing sky vistas. **by Michael A. Covington**

The best pictures that I take *with* my telescope are not ones I take *through* the telescope. Instead, I let the camera ride "piggyback" on top of a telescope that tracks the stars. The camera accumulates light during relatively long exposures, picking up deep-sky objects that cover moderately wide fields of sky.

Cameras and lenses

Most astroimagers use digital single-lens reflex (DSLR) cameras for piggyback photography. Film cameras also work well, although they prove to be more finicky than DSLRs.

You can use almost any lens. Most imagers use a medium telephoto, but you can get nice results with any focal length between 20mm and 500mm. Wide-angle lenses (those with shorter focal lengths) record more sky. For high-magnification shots, a compact, high-quality telescope can take the place of a long telephoto lens.

The lens doesn't have to be one made specifically for your DSLR. You can attach a manual-focus lens from an older film SLR with an adapter to your camera. (Go to www.fotodiox.com for a wide range of adapters.)

An off-the-shelf DSLR works well, but if you want to image emission nebulae, consider having it modified to extend its sensitivity to red light. Most DSLRs have filters that block long-wavelength visible radiation as a way to make daytime color photos look realistic. Unfortunately, this includes the prominent Hydrogen-alpha emission line in bright nebulae.

Astrophotographer Hap Griffin modifies cameras, Canon models in particular, to either remove or replace this filter (visit www.hapg.org). And Hutech Corporation (www.hutech.com/AstroCamera.htm) sells similarly enhanced DSLRs. The modification has little effect on stars and galaxies, but it makes faint emission nebulae pop.

With a digital camera, an f/4 focal ratio is fast enough. The camera's CCD sensor builds up light linearly and doesn't lose sensitivity during long exposures like film does. If you plan to use a film camera, you'll need the fastest lens you can get your hands on.

A mount with a polar view

In piggyback photography, the type of telescope you attach the camera to makes little difference, but the mount the telescope sits on is vital. With an alt-azimuth mount, the telescope has to twist with the stars even if its computerized motors track the sky perfectly. Because the field itself doesn't twist, the stars appear to rotate around the image's center during long exposures. To compensate, you'll have to shoot many short exposures, typically 30 seconds at most, and then rotate and stack them with computer software.

If at all possible, choose an equatorial mount. This type has its axis tilted to match that of Earth, so your target keeps the same orientation as Earth rotates. The mount's polar axis must match Earth's axis to within half a degree, or somewhat better if you don't make guiding corrections. Fortunately, this isn't hard to achieve. Here's how I do it.

I polar-align during twilight, and always with the drive and computer turned off. Although the telescope's built-in computer will offer to run a polar-alignment routine, in my experience, it's often confusing and not much help. Computers can overcome polar-alignment errors when finding stars, but they can't compensate smoothly when tracking them.

If your mount includes a tiny finder scope built into the polar axis, use this finder to align on Polaris and then shift slightly to the true pole. Otherwise, proceed as follows.

The Andromeda Galaxy (M31) is the biggest and brightest galaxy visible from the Northern Hemisphere. The author recorded M31 with a Canon 40D DSLR and a 300mm f/4 lens. He stacked two 6-minute exposures at ISO 800 and subtracted dark and flat frames. Michael A. Covington

Longtime astrophotographer **Michael A. Covington** *is a senior research scientist and associate director of the Institute for Artificial Intelligence at the University of Georgia.*

The Pipe Nebula (Barnard 59/65–7/78) in southern Ophiuchus ranks among the finest dark nebulae in the sky. The author captured this view with a Canon 40D DSLR and a 105mm f/2.8 lens. He stacked five 5-minute exposures at ISO 800 and subtracted dark and flat frames. Michael A. Covington

First, point the telescope in exactly the same direction as its polar axis. Don't blindly trust the 90° mark on the declination circle; test it if you suspect a problem. Once you align the scope, leave it in that position and make the rest of the adjustments with the mount only. Next, adjust the mount so Polaris lies in the center of the finder scope's field of view. Then move the polar axis 0.7° toward Kochab (Beta [β] Ursae Minoris), the brightest star in the Little Dipper's bowl. If your finder has the typical 5° field, you need to put Polaris one-quarter of the way from the field's center to its edge.

Now check your alignment with the drift method. The idea is that stars will appear to drift north or south if tracked with a misaligned mount. So turn on just the right ascension motor, or simply turn off both motors and track by hand-turning the right ascension knob.

A camera that piggybacks on an equatorially mounted telescope is the best way to photograph fairly wide swaths of sky. Bill and Sally Fletcher

Stop that drift

Unclamp the telescope from its 90° north position and aim it at a star high in the southern sky. Put an eyepiece with cross hairs in the focuser and rotate it so one cross hair runs east-west and then center the star. Try to keep the star centered by turning just the right ascension knob.

If, after 5 minutes, the star drifts north or south no more than 20" (equivalent to half the separation of Albireo's [Beta Cygni's] components or half of Jupiter's apparent diameter), you're done. Otherwise, if the star drifts north, move the polar axis a fraction of a degree to the right (or, if south, then left), re-center the star, and try again.

Last, perform the same test on a star that lies fairly low in the east or northeast. This time, if it drifts north, move the polar axis down, or vice versa. Once the drift rate falls below 20" per 5 minutes, you're done.

Now you can turn on the telescope's computer, conduct a one-star initialization (because the pole already provides a fixed point), and start taking pictures.

To guide or not to guide

In pre-digital days, you could tell who the serious astrophotographers were: the ones with stiff necks from spending hours staring in an eyepiece, keeping a star centered on cross hairs by constantly

Michael A. Covington

The region surrounding Gamma Cygni (the bright star at center) teems with star clusters and nebulae. The author took this image with a Canon 20Da DSLR and a 105mm f/4.5 lens. He stacked three 3-minute exposures at ISO 800 and subtracted dark and flat frames.

pressing buttons. It was the only way to make the telescope track the stars perfectly. Fortunately, those days are gone.

We had to make those guiding corrections for three reasons. First, polar alignment is never perfect; stars always drift a little north or south during a long exposure. Second, the motor has irregularities in its gears, which produces a "periodic error" that recurs with every turn of the shaft. And third, in really long exposures, refraction becomes noticeable — Earth's atmosphere causes objects near the horizon to appear a fraction of a degree higher than they really are.

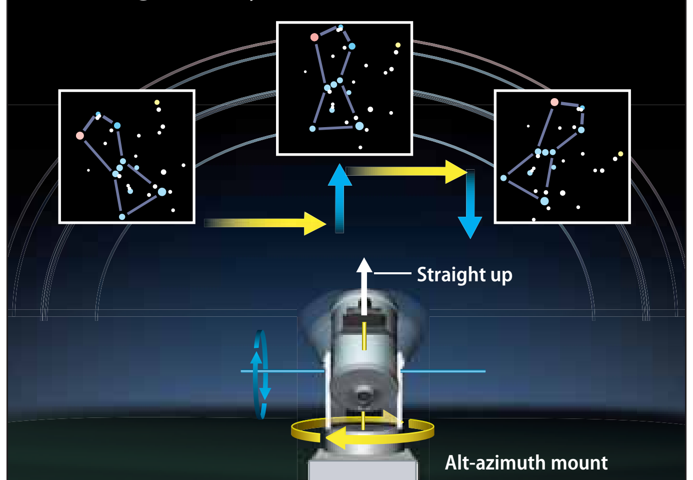
With film, we had to guide perfectly for half an hour or longer. In the digital age, we can take sets of 2-minute exposures and use software to stack them. So, errors that don't show up in 2 minutes won't show up at all, occasional jerks in the guiding can be left out, and any gradual drift disappears when you align the pictures for stacking. As for periodic error, you now make the corrections once, with a cross-hair eyepiece, and the computer will remember and replay them on subsequent cycles. And short exposures keep atmospheric refraction from becoming a problem.

The bottom line? With a focal length of less than 200mm, you don't need to make guiding corrections. With a high-quality mount and good polar alignment, you may not need to make them even with longer focal lengths. Many astrophotographers simply refine the mount's alignment and performance so they never have to make corrections while taking an exposure.

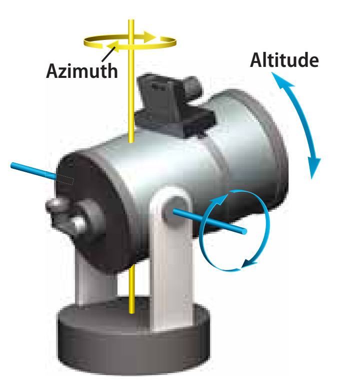
Others, including me, still do so. (There's no substitute for peace of mind.) But we no longer gaze into an eyepiece and press buttons — we use autoguiders. An autoguider can be a self-contained instrument or a software package (such as *PHD Guiding*, available for free from www.stark-labs.com) used with a webcam or planetary video camera. The autoguider watches a star through the main telescope and issues corrections to keep the telescope pointed at it. The piggybacked camera reaps the benefits of perfect tracking.

You have a wide range of celestial objects to target with your piggyback setup. You'll get nice results photographing nebulae, star clusters, and galaxies that span anywhere from roughly 1° to several degrees. A good rule of thumb:

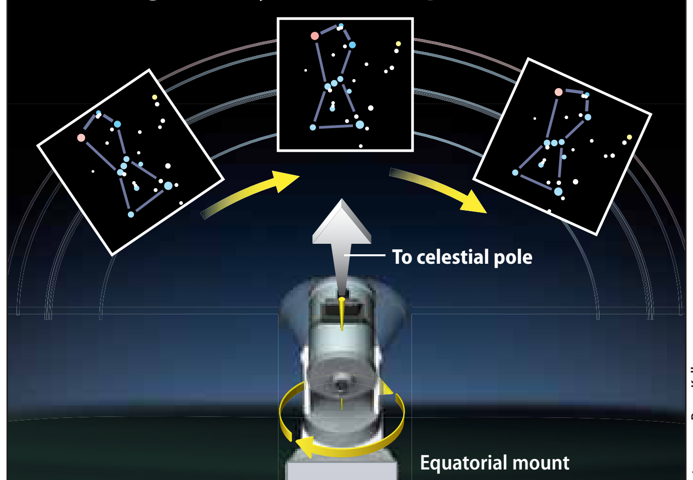
Tracking the sky with an alt-azimuth mount



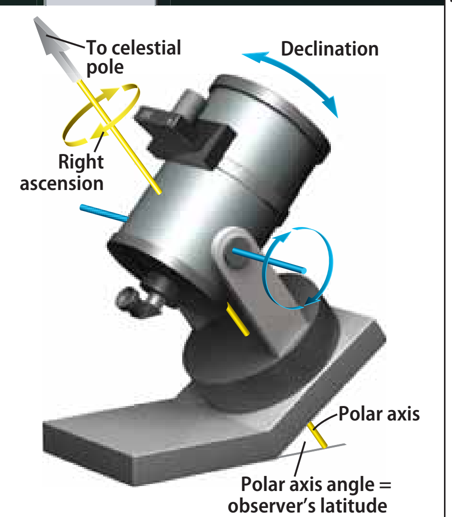
With an alt-azimuth mount, the telescope (and any attached camera) keeps the same orientation relative to the horizon and must track the sky by simultaneously moving in two axes (left-right and up-down). The celestial target thus rotates in the camera's field of view.



Tracking the sky with an equatorial mount



With an equatorial mount, the telescope (and any attached camera) rotates with the sky. The target thus keeps the same orientation relative to the camera's field of view.



Astronomy: Roen Kelly

The Pleiades star cluster (M45) shows up nicely even under suburban skies. The author took this image with a Canon Digital Rebel DSLR and a Nikon 300mm f/4 lens from a residential area. He stacked six 3-minute exposures at ISO 400 and subtracted dark frames. Michael A. Covington

Choose your targets by looking for objects plotted as shapes and not mere dots or symbols in star atlases. Although you need a dark sky to record galaxies and nebulae, star clusters and the brighter parts of the Milky Way produce fine pictures even from suburban sites.

Exposure and processing

When you shoot the sky, use the same procedures you would for any deep-sky photography. With a DSLR, set the camera to ISO 800, tell it to record raw files (not JPEGs), and turn off "long exposure noise reduction" so the camera doesn't take dark frames automatically.

When you're ready to take a picture, use live focusing (Canon calls it "Live View") if your camera has that feature. Otherwise, take short test exposures to verify focus; don't trust the infinity mark on the lens. Then, under full manual control, take a series of 2- to 5-minute exposures followed by a matching set of dark frames with the lens cap on to record CCD noise. Canon and other companies make timers that can be set to take a series of sky exposures with one press of the button.

Many astroimagers also take a set of "flat fields" to compensate for edge-of-field darkening and dust on the sensor. You should take these through the same lens at the same f-stop, but not necessarily the same ISO speed. Let the camera auto-expose (using "A" or "Av" so your selected f-stop remains in force) while you photograph something featureless and gray. I usually take flat fields during twilight with a white handkerchief in front of the lens. You can also hold a light box in front of it.

Now you need to combine your exposures and subtract the dark frames. Many software packages do this well, but my current favorite is *Deep Sky Stacker* (free from http://deepskystacker.free.fr). It outputs a TIFF file that you can edit with Adobe *Photoshop* or similar image-processing tools.

The final step is to adjust brightness and contrast. "Auto Levels" in *Photoshop* often works miracles, but you'll probably want to make final adjustments manually. Then save the result and enjoy it.

This is part three of Michael Covington's imaging series. He will look at prime-focus astrophotography in a future issue.

Michael A. Covington

The Lagoon and Trifid nebulae (M8 [below] and M20, respectively) in Sagittarius make stunning targets for piggyback photographers. The author shot this scene with a Canon 20Da DSLR and a 300mm f/4 lens. He stacked eight 4-minute exposures at ISO 800 and subtracted dark and flat frames.

To read the previous two parts of this series, visit www.Astronomy.com/toc.