How-To: Astrophotography 101

Don't put that camera away when it gets dark, get outside and take pictures! A whole universe of wonderful images awaits you.

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Our cameras get most of their workouts during the daytime, when there's plenty of light from the sun to illuminate our subjects. If we shoot at night, it's usually with a flash attached to brighten things up, or with long exposures using man-made light from our streets or houses. That big dark sky above us at night seems to offer little that we can see or photograph... but that's not the case. There's not just a whole other world of things to take pictures of in that dark sky -- there's a whole universe of opportunity. This how-to article will provide the basics to let you start taking dramatic photos of the sky at night.

Astrophotography is the name given to the process of taking pictures of anything not on the Earth, but out in space. Most of us probably think of images from the Hubble Space Telescope when the word is mentioned, but making good astrophotos doesn't require billions of dollars or a ride in the Space Shuttle. This article will show you how to start making photos with equipment almost every photographer has on hand, progress to the next level with some simple equipment you can buy inexpensively or make yourself, and finish with what you can do if you decide to invest in some specialized (and sometimes expensive) equipment.

The first thing to remember when getting into astrophotography is that the earth rotates on its axis once per day. Obvious? Sure, but what it means for astrophotography is that you're never trying to capture a "still" object. The earth's rotation makes the stars, planets, and the moon appear to move across the sky all night long. The moon and planets also have their own motions, which complicate matters. And since most of the things we'd like to take photos of are awfully dim compared to a typical subject in the sunlight, we're going to have to use long exposure times to gather enough light to see them, and they'll be moving (or appearing to) the whole time. There are only two ways around this constant movement: ignore it, or compensate for it.

Fixed-Position Astrophotography

Let's start with what we can do by ignoring the earth's rotation. Shooting these kinds of photos only requires a camera capable of long exposures (a "B" or Bulb setting, or exposure settings from 30 seconds to several hours). The obvious example is "star trail" images.

The earth rotates on its axis at about 1/2-degree per minute -- so the stars will appear to rotate that same amount overhead. If we set a camera on a fixed tripod, open the shutter, and let the earth rotate us under the stars, we get an image that shows the stars as "streaks" or trails as they appear to move across the sky. The longer we leave the shutter open, the longer the trails will

be in our final image. The image shown here was exposed for about 60 minutes, giving 15-degrees of arc to each star trail. Notice in the image that near the center there appears to be almost no star-trailing, and as you move further out the star trails appear to get longer. That's because the camera was pointed right at the center of the earth's rotational axis: Polaris, or the North Star. Since this is the center of rotation, there's the least amount of apparent movement near this axis. As you move further away from this point, stars will appear to move more and more in a straight line until you reach the "celestial equator" (90-degrees from the North Star in the sky), where the trails are perfectly straight and will appear longer.

Here's how to take star-trail photos:
• Use a sturdy tripod, and secure it in place or weight it down if you can. Any movement of the tripod will show "squiggles" in your star trails.
• Use a fairly wide-angle lens for best results, the 35mm equivalent of 20-50mm focal length is a good place to start.
• Choose a medium-speed film or a digital-camera ISO of 400-800. That's high enough to record even fairly dim stars, but it shouldn't introduce too much grain or noise.
• Set a medium aperture of f/5.6 to f/11. The stars won't change much in brightness no matter which aperture setting you use, but smaller apertures will reduce the brightness of "skyglow" from nearby towns or other light sources.
• Select a dark location away from city lights if possible. Include something interesting in the foreground (such as the trees above) to give scale to the image and to help show the sky's apparent rotation against the earth.
• Make sure you have new or freshly-charged batteries in your camera. Holding the shutter open for long periods drains batteries fast! If your camera has a DC car-power adapter, or a battery pack, use them.
• Use a cable release or remote release, set manual focus, focus on infinity (put a small piece of masking tape on the lens' focus ring to hold it if you can), and open the camera's shutter. Leave it open as long as possible. Longer exposures mean longer star trails, but also pick up more "sky glow.

Star-trail images can be spectacular, but due to the motion of the stars, they can be somewhat "abstract." What if you want to take an image of the stars as we actually see them?

As mentioned before, the stars appear to move at about 1/2-degree per minute across the sky. If we use a wide-angle lens (which has a wide field of view), you can leave the shutter open for a short while before that movement becomes visible in the image. The stars will still be "trails" in your picture, but the trails will be so small they're indistinguishable from single points. In the image above, I used a 14mm lens (with a field of view of 104-degrees horizontally and 81-degrees vertically), and exposed for 30 seconds. In that time, the stars moved less than 1/4-degree, taking up less than 1/400th of the horizontal field of view. In the full-sized image you can see that they're little trails, but just barely. This kind of image shows the sky as we appear to see it with our eyes. Only the brightest stars will show up clearly this way, but as you can see from the image above you can clearly make out the constellation Orion, the Pleiades star cluster, and other constellations and stars.

Here are some tips for shooting non-trailed fixed-position star images:
• Use a very wide-angle lens -- the wider the better. At 28mm (35mm film equivalent) focal length, you can expose for about 20 seconds without significant trailing. At 50mm, you can only expose for about 10 seconds, which is only long enough to record the very brightest stars. At 14mm, you can shoot for 30 to 40 seconds, which should show more lower magnitude stars.
• As with star-trail images, include something interesting in the foreground! The image above was shot on a night when the nearly-full moon was just rising in the east, and the camera was aimed west, away from the moon. The moon illuminated the foreground without washing out the sky.

• The same setup rules apply as with star-trail images; use a sturdy tripod, a remote release, ISO 400-800, and f/5.6 to f/8.

The Moon

There's one night-sky target we haven't covered yet. I saved it until last because it's one of the easiest to take pictures of... our Moon. While the moon appears to move across the sky at nearly the same rate as the stars, it's very bright -- about the same brightness as a daylight scene on Earth (since the light we see from the Moon is just reflected sunlight, that makes sense!). Since it's so bright, it doesn't require the long exposure times that are needed for stars, galaxies, etc. But the Moon can be a great target to photograph.

The issue with taking pictures of the Moon is really focal length of the lens you're going to use. On 35mm film or full-frame digital cameras, it takes a focal length of about 2000mm to fill the frame with the Moon. APS-C DSLRs need about 1200mm to do the same. While you can get satisfactory Moon pictures with shorter focal lengths, the closer you can come to those frame-filling ideals, the better.

Proper exposure values for the Moon are easy to figure out -- just use the "sunny 16" rule. At f/16, use a shutter speed that is the reciprocal of your film or sensor's ISO value; at ISO 200, you'd use 1/200th sec. at f/16. Adjust the shutter speed up or down according to how many f-stops above or below f/16 your lens is operating at. Use a sturdy tripod, use your camera's mirror lock-up function (if it has one), and use a remote or cable release. Focus at infinity, and shoot away. It's best NOT to use your camera's auto-exposure modes; most camera exposure meters see all that black surrounding the Moon, and add exposure time to compensate, which over-exposes the Moon itself.

If your goal is to shoot frame-filling photos of the Moon showing lots of detail, the best time to shoot isn't when it's full: at full Moon, the Sun is lighting the Moon face-on. Just as with your on-camera flash, straight-on lighting is flat, boring, and doesn't provide any shadow details. Try taking Moon pictures at first or third quarter (when the Moon appears half-lit, as above). At these times, the Sun provides side-lighting, showing relief on lunar surfaces and providing interesting shadows. Try not to shoot Moon pictures when it's low on the horizon. At those positions you're shooting through the thickest part of Earth's atmosphere, and the turbulent, moving atmosphere makes it difficult to see fine details on the lunar surface. Wait until the Moon is high in the sky, where the atmosphere is thinnest, even if that means getting up at 2AM to shoot!

Another way to shoot pictures of the Moon is to include it in landscape shots for dramatic impact. You can use much shorter focal lengths than for the frame-filling detail shots, but stay on the longer side (100mm or above) or the Moon will look very small in the image. The same "sunny 16" exposure guide applies, with a caveat: when the Moon is near the horizon, the thick layer of atmosphere you're looking through to see it will dim its light, sometimes dramatically. When it's near the horizon, start with about two stops more exposure than when it's high in the sky, and bracket your exposures if you can. For the moonrise image above I used about three stops more than the "sunny 16" guideline. A full Moon will rise in the east about the same time the Sun is setting in the west; a crescent Moon will rise just before sunrise in the east or set just after sunset in the west. Balancing the near-daylight exposure for the Moon with twilight can be tricky, making sunrise and sunset the best times to shoot. Just be careful not to over-expose the Moon or you'll wind up with a white blob that shows no detail.

I hope this How-To has piqued your interest in the possibilities of astrophotography. Don't put that camera away when it gets dark, get outside and take pictures! A whole universe of wonderful images awaits you.