Simple techniques

Part I

Welcome to astrophotography 1

Welcome to astrophotography! This book is for people who want to take pictures of the stars and planets, and, perhaps more importantly, who want to understand how astrophotography works. The earlier chapters contain instructions for beginners, and the later chapters are more like a reference book.

My goal is to show you how to do astrophotography at modest cost, with the equipment and materials an amateur can easily obtain and use. I haven't covered everything. I've concentrated on 35-mm cameras and relatively inexpensive telescopes, 20-cm (8-inch) and smaller. Techniques that require unusual skill or expenditure are mentioned only briefly with references to other sources of information.

1.1 The challenge of astrophotography

Why photograph the sky? Because of the great natural beauty of celestial objects, because your pictures can have scientific value, and, perhaps most importantly, because you enjoy the technical challenge. Astrophotography will never be a matter of just taking snapshots, and Kodak's old slogan, "You press the button, we do the rest," certainly doesn't apply. Astrophotographers push the limits of their equipment and materials, and a good astrophotographer has to know optics and film the way a race-car driver knows engines. There are three main technical challenges:

- Most celestial objects require magnification; that's one reason we use telescopes. (Not all objects require magnification; star fields, meteors, and bright comets can be photographed with your camera's normal lens.)
- Many celestial objects are faint, requiring long exposures to accumulate light on the film. In fact, astronomical discoveries have been made this way; the Horsehead Nebula and Barnard's Loop are too faint to see with any telescope, but are not too hard to photograph.
- Whenever high magnification or long exposures are involved, the rotation of the earth gets in the way by making the sky seem to move continuously. To compensate for this motion, telescopes have equatorial mounts and drive motors. Sometimes the camera rides "piggy-back" on the telescope while taking a picture through its own lens (Fig. 1.2).

Almost everything in this book deals with how to overcome one, two, or all three of these challenges in a particular situation. It's not always easy; some kinds of astrophotography are much harder than others, and I present the easier techniques first.

Fortunately, you don't have to master the hardest techniques in order to get impressive pictures. Piggy-backing and moon photography are particularly rewarding even though they require only modest effort and simple equipment. Photographing galaxies is especially hard; so is high-resolution photography of the planets.

1.2 Choosing equipment

Never buy a telescope or camera unless you understand exactly what it will do for you and how it will do it. Always educate yourself first, because the equipment doesn't take the pictures; *you* do. Chapter 9 gives detailed advice on choosing cameras and telescopes, but your knowledge should always run ahead of your equipment.

Learn the sky before buying a telescope. It goes without saying that if you can't point your finger at M31 or the Orion Nebula, you won't be able to point a telescope at them either. I usually tell young amateur astronomers that they're not ready for a telescope until they can identify at least five constellations and three

Figure 1.1 **The moon photographed at the prime focus of a 12.5-cm (5-inch) *f*/10 Schmidt–Cassegrain telescope. A half-second exposure on Kodak Technical Pan Film developed in Technidol LC; clock drive running. (By the author)**

Figure 1.2 **The author gets ready to photograph star fields with a camera and 180-mm lens mounted "piggy-back" on a 20-cm (8-inch) Schmidt–Cassegrain telescope. (Melody Covington)**

interesting objects (planets, star clusters, or the like) without a map. Don't be seduced by computer-controlled telescopes; they save time if you have a busy observing program, but you can't use them effectively unless you already know the sky.

Full advice for beginning stargazers is beyond the scope of this book, but any of the major magazines (*Sky & Telescope*, *Astronomy*, or *Astronomy Now*) will quickly lead you to all the other sources of information.

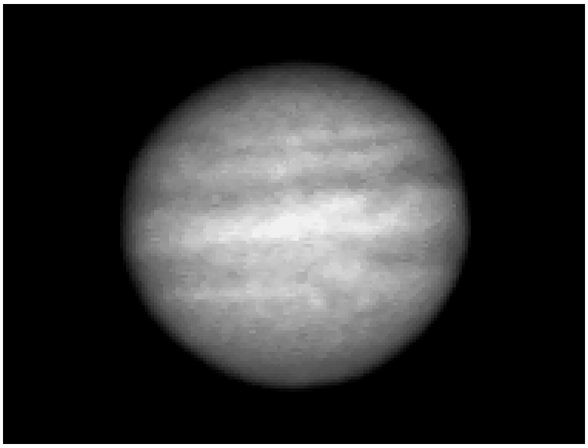

Figure 1.3 **CCD image of Jupiter, taken with 20-cm (8-inch) $f/10$ Schmidt–Cassegrain telescope and $\times 2$ Barlow lens. Exposure 100 milliseconds with Meade Pictor 216XT camera. The image was processed by unsharp masking to bring out detail. (By the author)**

The publishers' addresses are in Appendix F, along with addresses of useful astronomy sites on the World Wide Web.

Useful books for beginners include Patrick Moore's *The Amateur Astronomer* and Liller and Mayer's *Cambridge Astronomy Guide*; the latter emphasizes using a camera rather than a telescope, so its point of departure resembles Chapter 2 of this book. More advanced observers should not miss Martinez' two-volume *Observer's Guide* and Burnham's *Celestial Handbook*. As a handbook of astronomical science, including astrophysics, I particularly like *Fundamental Astronomy*, by Karttunen *et al*., because it doesn't leave out the mathematics; you can skip the mathematical portions if you like, then go back reread them if you feel the need.

1.3 Sharing your work with others

Once you have some good astronomical photographs, what do you do with them? You could join the legions of amateurs who send their pictures to major astronomy magazines. Unfortunately, your chances of getting a picture published that way are slim; none of mine ever have been! With hundreds of excellent pictures coming in every month, astronomy magazines can print only a few that are truly exceptional.

Instead, look for other ways to share your pictures with your friends and the public. Enter them in local photography contests. Assist the local newspaper with pictures of eclipses and comets. Give slide shows for school children and science clubs. Decorate your home and office with enlargements. Sell prints at art shows. Make Christmas cards. Do anything any other photographer would do, remembering that unlike most people's, your photographs probe the limits of the universe.

Figure 1.4 **An example of very advanced amateur work. The galaxy NGC 253; a 60-minute exposure on hypersensitized Kodak Technical Pan Film with a 14-inch *f*/7 telescope. (Chuck Vaughn)**

Figure 1.5 **A picture well worth sharing: the moon rising over Lick Observatory. Richard A. Milewski carefully calculated the position of moonrise to take this picture.**

1.4 Maintaining balance and enjoyment

Let me end with an exhortation: remember that we do this because we enjoy it. Like most amateur astronomers, I am in the middle of a thriving career in something else (computational linguistics in my case) and have neither an unlimited budget nor a perfect observing site. But that's part of the challenge – to make intelligent and creative use of limited resources. Astrophotography is not a competitive sport, the beauty of a picture is not proportional to the difficulty of taking it, and your pictures don't have to be the best in the world in order to be satisfying. As G. K. Chesterton put it, "Anything worth doing is worth doing badly" – that is, worth doing even when you're not an expert.

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Excerpt
More information

Photographing stars without a telescope

2

By making time exposures with an ordinary camera, you can photograph more stars than your unaided eye can see, and your photographs will show the colors of the stars vividly. This chapter will tell you how to photograph the starry sky with minimal equipment, how to maximize picture quality, and how to put your pictures to practical use.

2.1 Stars and trails

To get started in astrophotography, all you really need is a camera that can make time exposures, a tripod or other steady support on which to mount it, and a cable release that will allow you to open the shutter and latch it open without vibrating the camera. Load your camera with color slide film rated at ISO (ASA) 200 or faster, go out on a starry, moonless night, aim the camera at a group of bright stars, open the lens to its widest f-stop, and make two time exposures – 20 seconds and 5 minutes (Fig. 2.1).

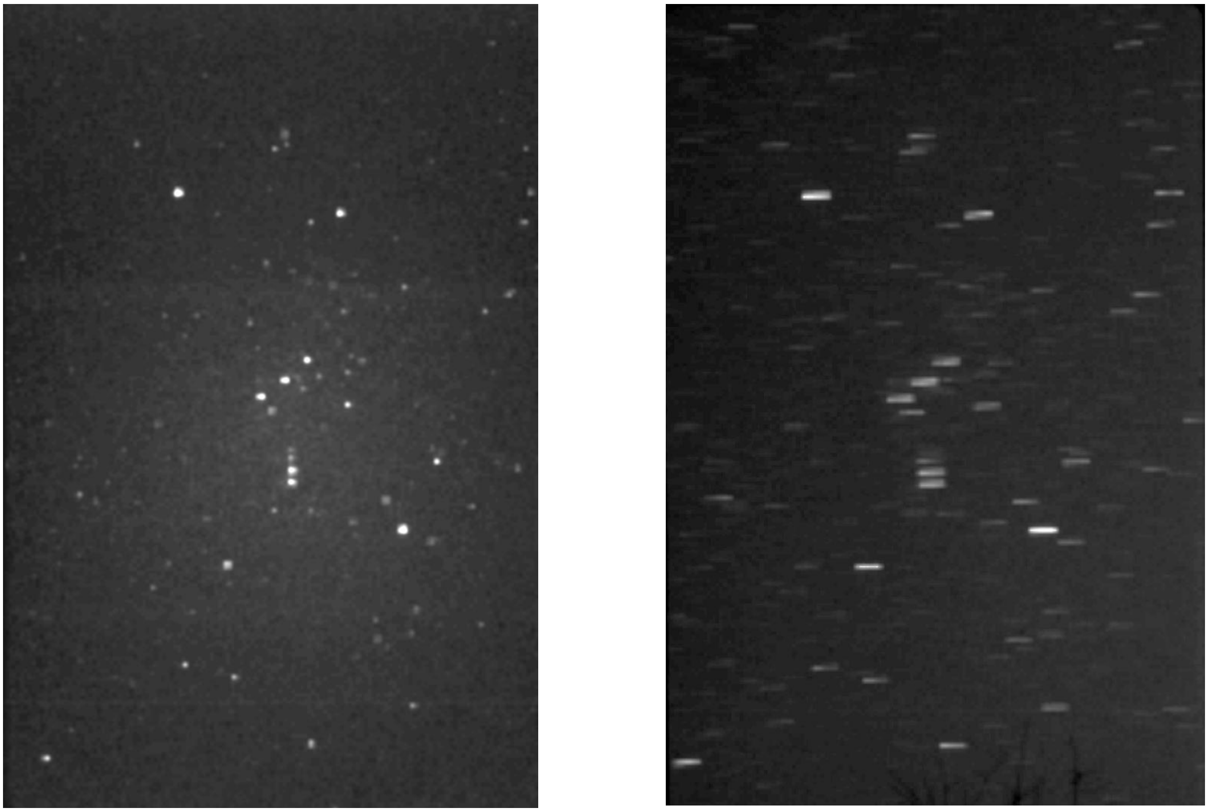

Figure 2.1 **Twenty-second and five-minute fixed-tripod exposures of Orion. Fuji Sensia 400 film, Minolta 50-mm *f*/1.7 lens wide open. (By the author)**

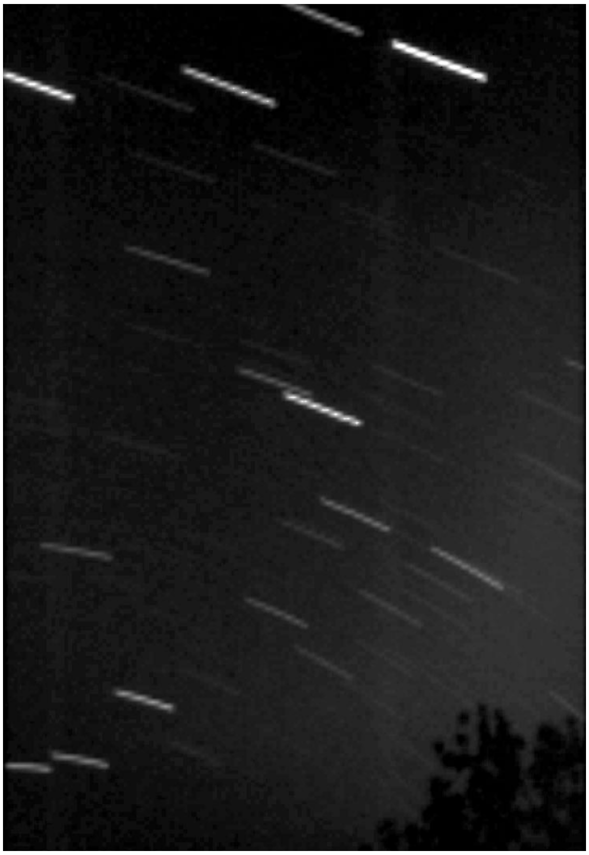

Figure 2.2 **Star trails – this is what happens when you expose much longer than 20 seconds. A 30-minute fixed-tripod exposure of the constellation Bootes taken in 1982 on Ektachrome 200 Professional with a 24-mm wide-angle lens at *f*/4.**

Figure 2.3 **Star trails centered on Polaris – but mostly the lights of a nearby town. A 30-minute fixed-tripod exposure taken in 1982 on Ektachrome 200 Professional, 24-mm lens at *f*/4. Compare this with Plate 2.1, which was taken in the country.**

When you get your film developed, look at the results. The 20-second exposure should show the stars much as they actually looked in the sky – but if you look carefully, you'll see that the film caught some stars that were too faint for you to see. In the 5-minute exposure, though, the stars won't look like stars. The star images will be short lines or curves instead of points – and if you exposed longer, the lines or curves would be longer. It's as if the stars had been moving.

In reality, of course, it's the earth that moves; the earth's rotation is fast enough to create star trails instead of point images even on exposures as short as a minute or two. Stars directly above the earth's equator appear to move in straight lines; those in the northern or southern sky appear to trace circles around whichever of the two celestial poles is nearer. To see a dramatic demonstration of this effect, aim your camera at Polaris and expose for perhaps two hours at *f*/8 – or look at Figs. 2.2 and 2.3 and Plate 2.1.

Another difference between the 2-minute and 10-minute exposures involves *sky fog* – the sky background looks much lighter in the longer exposure. The reason is that the night sky isn't perfectly black (it's often deep blue or green), and the film picks up background haze that is too faint for your eye to see. The longer the exposure, the more sky fog the film records. Sky fog is a constant nemesis of astrophotographers; we'll consider it more fully in Chapter 8. In the meantime, Basic Technique 1 sums up the procedure for making a short exposure of a star field.

2.2 BASIC TECHNIQUE 1: Photographing stars without a telescope

Equipment: Camera capable of time exposures, fast 50-mm lens, tripod, latching cable release.
Film: Color slide film, 200 to 1600 speed. Print film can be used if you can obtain custom prints; automatic machine prints are likely to be disappointing.
Sky conditions: Clear moonless night. Some city light is tolerable as long as stars are clearly visible. No lights should shine directly on the observing site.
Procedure: Place the camera on the tripod and aim it at a bright group of stars in the sky. Set the lens opening to $f/1.8$ or $f/2$ and focus on infinity. Expose for 20 seconds.
Variations: Near the northern or southern celestial pole, you can expose a good bit longer than 20 seconds. Elsewhere in the sky, longer exposures will render the stars as streaks instead of points.

Wide-angle lenses permit longer exposures; telephoto lenses require shorter exposures if you don't want streaks.

2.3 How long can you expose?

As long as you're using a fixed tripod and want to get images that look like stars rather than trails, the motion of the earth limits how long you can expose. The practical limit for a particular picture depends on two things, the focal length of the lens and the position of the stars in the sky.

The focal length matters because longer lenses make everything look bigger, including the motion; hence the same amount of motion will be more visible when you use a telephoto lens. Thus telephoto lenses require shorter exposures. Wide-angle lenses make everything look smaller, including the motion, so they let you expose longer.

The position of the stars also makes a difference because the nearer a star is to the celestial equator, the faster it appears to move. The distance from the equator to a star is called the star's *declination* and is expressed as an angle, like latitude on earth; stars with higher declinations move more slowly and allow longer exposures. You can probably get away with a 45-second exposure of the Big Dipper (Plough) because of its high declination (about +60°).

To be precise, the length of the streaks depends on the cosine of the declination. Thus, if 20-second exposures look acceptable when taken with a 50-mm lens aimed at the celestial equator, the longest acceptable exposure, t, at any declination, with any lens, will be:

$$t \text{ (in seconds)} = 1000/(F \cos \delta)$$

where F is the focal length of the lens, in millimeters, and δ is the declination of the star. Where did we get 1000? It's simply 50 (the original focal length) times 20 (the original number of seconds). Table 2.1 gives some values computed with this formula.

If you want perfectly crisp, round star images, the exposure has to be shorter. Use this formula instead:

$$t \text{ (in seconds, for sharp stars)} = 343/(F \cos \delta)$$

This formula ensures that the trails are less than 1/40 mm long, short enough to be hidden by the limited resolution of the lens and film.

Those formulae apply to 35-mm cameras and other formats that are essentially the same size, such as APS and 126. If you're using 120 film, which is about twice as wide, you can probably expose twice as long because the streaks won't be enlarged as much when you make the print. But your normal lens will be 80 to 100 mm rather than 50 mm, so your normal exposure near the celestial equator will still be 20 seconds.

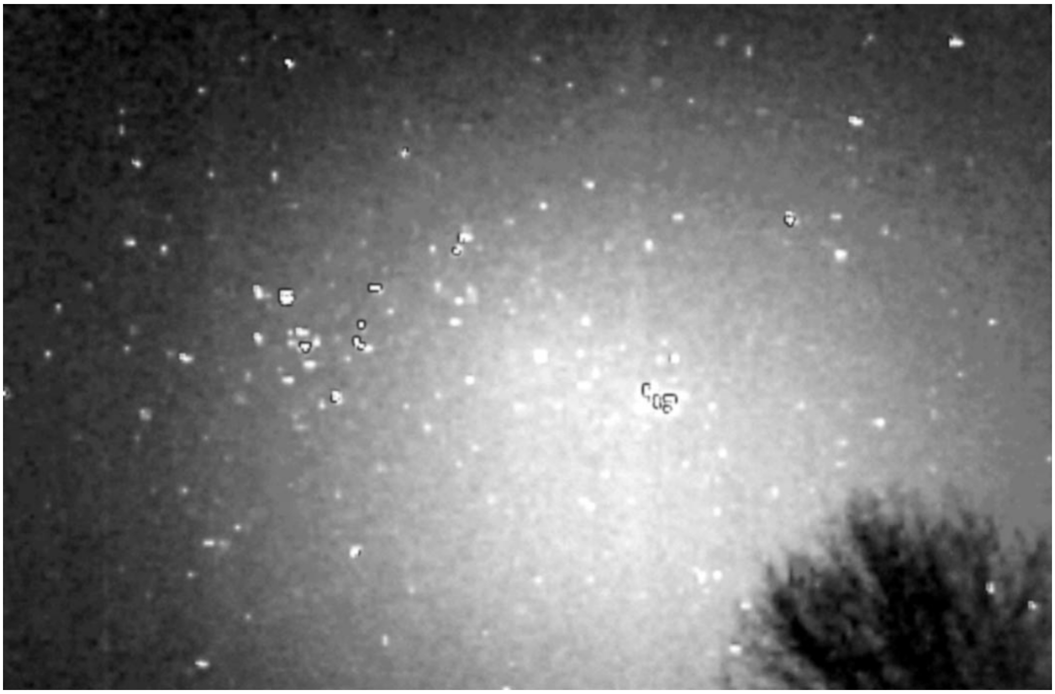

Figure 2.4 **The Hyades and Pleiades, two prominent star clusters in Taurus. A 20-second fixed-tripod exposure on Fuji Sensia 400 film, Minolta 50-mm *f*/1.7 lens wide open. (By the author)**

Figure 2.5 **The familiar Big Dipper or Plough (Ursa Major). A 30-second fixed-tripod exposure, 50-mm *f*/1.8 lens wide open, Ektachrome P1600 film. (By the author)**