CHAPTER FOUR

Urban Observing Techniques and Projects

All amateur astronomers, as they grow and progress in this wonderful hobby, develop a "bag of tricks," techniques that allow them to squeeze every last detail and every last photon out of their telescopes. In the city, it is especially important to take full advantage of all the light our scopes can gather. In large part, taking advantage of everything your scope can do for you is a matter of experience. Observe more and you'll see more. But there are some specific techniques you can learn that will improve your city observing results.

Averted Vision

Most deep sky observers are well aware of a special characteristic of the human eye: it is more sensitive on the periphery of its visual field than it is at the center. The retinas of your eyes are composed of two different types of light receptors, rods, and cones. Rods, which are found in greater numbers away from the center of the retina, are considerably more sensitive than the cones. The cones handle color vision, while the rods are essentially color blind, explaining why it is so hard to see color in dim astronomical objects. If an object is so dim that you need your rods to see it, you just won't detect color. The human eye and the image processing done by the brain is a very complex subject, and this description of the eye's light-sensing characteristics is grossly oversimplified, but the fact is, you can see dimmer details of an object (or even make an invisible object appear) by *looking away from it* rather than *right at it*. This is averted vision.

The funny thing is that amateur astronomers who know this technique and use it regularly while observing from dark country skies seem to forget to use it in the city. While the improvement in your ability to see dim objects and details using averted vision may not be quite as dramatic with bright-background city viewing, the gain is still quite real and can result in your seeing a dim galaxy with ease instead of adding it to a sadly long "not seen" list.

Jiggling the Telescope

There's another characteristic of the human eye you can take advantage of in your quest to see faint objects. The human eye can distinguish moving objects more easily than stationary ones, an adaptation that may have allowed our distant ancestors to quickly detect moving predators out on the veldt. If you can't make out an object with averted vision, try gently tapping on the tube. You may find you can see your dim target as long as the telescope is vibrating.

Dark Adaptation

Have you ever gone from a bright sunny afternoon into a dark motion picture theatre? Once inside, you are not surprised to find that you're practically blind for a while. After about 5 minutes you'll find your sight returning, with colors becoming more visible as your cones adapt to the darkness. Over the course of approximately 30 minutes, your rods attain their full sensitivity. Slight improvements in your dim-light vision may continue for a considerable length of time after that. The adjustment of the rods and cones to dim light is caused by the production of a chemical called *rhodopsin* or "visual purple." The amount of this substance in your rods and cones determines how sensitive they are to light. Exposure to bright light bleaches rhodopsin out of the eye and causes it to become temporarily less sensitive to light.

Dark adaptation is actually a two-part process. In addition to time in the dark needed to allow your eyes to recharge their rhodopsin, your eyes' irises also have to have time to dilate. Your irises are small diaphragms that can open or constrict to let in more or less light, ensuring that your retinas receive a sharp and properly "exposed" picture. The iris of your eye works exactly like the *f*/stop diaphragm in a camera, which was modeled on the working of the human eye. A normal human iris will open from 6 to 8-mm depending mainly on the age of the observer (older peoples' irises open less wide than those of youngsters). For your eyes to attain their best dark adaptation, they need to be in total darkness for at least 30 min. Unfortunately, that's tremendously difficult to do in the city.

As was pointed out earlier, there's nothing you can do about city sky glow. It's there, and that alone will prevent you from reaching full and complete dark adaptation. But if sky glow were all you had to worry about, your eyes could actually attain a good degree of dark adaptation in most locations. What prevents dark adaptation in the city is ambient light. A neighbor's nearby security light or even the light shining from a curtained window will radically reduce your eyes' final dark adaptation. They'll only become sensitive to dim light *to a degree*, and if you accidentally look straight into a streetlight or security light, your dark adaptation will have to start over from square one. Fortunately, ambient light can be dealt with.

One approach, as discussed in the site selection section, is to choose an observing location with minimal ambient light—no bright lights shining directly on you and, if possible, nothing other than the general sky glow illuminating your and your telescope. Naturally, this is often impossible in the urban environment, where dozens of ambient light sources are present. The next best approach is *blocking*.

The idea is to shade your telescope from all ambient light. Put up a shield of some kind. This shield can be as simple as an opaque sheet of vinyl or cloth hanging on a line strung between two posts. Almost anything can be used as a light shield, from a sheet of plywood propped on a step-ladder to a large piece of cardboard hung from a tree limb. Some manufacturers have gone so far as to produce portable temporary observatory domes made from tent canvas. These can be extremely effective, but assembly is a complicated annoyance if you have to put them together for every viewing session. Most, however, are durable enough that they can be left erected for weeks during favorable observing weather if local codes/covenants and your spouse allow.

I didn't want to spend the money for one of the tent-type observatory domes, but recently got tired of trying to prop pieces of cardboard or plywood against a step-ladder and trees. While my shields worked well, they were difficult to move around, and a sudden gust of wind would usually send the "wall" of my "observatory" crashing into my scope or my head. I came up with a design for an easy to use, movable light-shield one night as I was attending a play at the theatre. Why not use stage flats? Flats, painted stage scenery, are made of canvas stretched on a frame of 1 × 4 lumber, and are held in place by a brace and a sandbag. This sounded like something that could be adapted into an easy-to-move light-shield. Stagehands move scenery all the time, and in the smaller sizes I'd use (stage flats can be as much as 12 feet high), portability wouldn't be an issue. As a test, I constructed a 4 foot wide by 6 foot high frame of 1 × 4 lumber connected at each corner with a triangular piece of $1/4$ inch plywood held in place by wood glue and screws. A triangular brace, also made of 1 × 4 lumber, was attached to one vertical 1 × 4, and was held in place with a concrete block or bricks (though sandbags as used in the theatre will work if you want to go to the trouble to make them). A piece of inexpensive muslin from a fabric store was stretched over this frame and stapled in place. My "flat" was then painted with enough coats of black latex paint to make it impervious to light.

In use, I position my flats/light shields (Plate 14) as needed to keep ambient light off me and my telescope. If you have severe ambient light problems, you may want to construct three or four or more of these shields. They can be linked together with door hinges (perhaps with their pins replaced by removable rods or nails for easy disassembly) or eye and hook latches to provide a sturdy shield. By using inexpensive pine lumber I kept my cost to a minimum, and, considering the small expenditure, the improvement in my observing conditions has been dramatic. In addition to blocking stray light, my well-braced stage-flat "observatory" also helps protect the scope from wind, ensuring steady views on those good winter nights after a front has passed through.

If you don't like my stage flat observatory idea and want something more elegant, you might make shields with frames constructed from PVC pipe. This can be arranged so that the pipes screw together, meaning the light shield can be disassembled for storage. Instead of muslin, a lightweight, opaque vinyl tarp, possibly attached to the pipe frame with elastic cords, might be nice. But my humble stage flats work incredibly well for me.

Speaking of observatories, that's not a bad idea. Dark sky observers would probably find the idea of a permanent urban observatory hilarious, but an observatory is perhaps even more useful in the city than in the country. In the city, a real observatory provides the same great luxury it does in the country: a permanent place where you can leave the scope set up so you can observe happily at a moment's notice. Not having to haul the scope and accessories in and out means you will observe a *lot* more, especially on weeknights. In addition, a properly designed observatory can end your problems with ambient light forever, effectively blocking everything but the night sky.

An urban observatory can be built exactly the same way as a country one, with roll-off roof models like the one shown in Plate 15 being easier to make and more popular than traditional domed installations. The only city-peculiar considerations are a possible need for higher security, which can be easily provided by adequate doors and locks, and a need to deal with building codes, which are not often a hindrance out in the country. If security is a consideration for you, I'd suggest that you might want to forego a traditional dome and do a roll-off roof observatory. A dome is beautiful, but calls attention to itself, and may be an irresistible magnet for vandals and thieves.

It is beyond the scope of this book to show you how to build an observatory, but the process of putting up a secure, attractive, and useful building is not difficult, especially if you have friends experienced in building or remodeling. Even if you don't have access to someone with that kind of talent and don't have it yourself, you may not be destined to do without an observatory. Your local library will have books in its "home improvement" section that provide step-by-step instructions on constructing small outbuildings and sheds. Combine these plans with details of amateur observatories found in amateur astronomy books and magazines and your long-dreamed-of-facility can become a reality. If this seems too daunting, it is also possible to modify the prefabricated outbuildings that are available from many sources. Your observatory does not have to be fancy; the only requirements are that it provides a secure, dry home for your scope, shield you from ambient light, and allow you to see as much of the night sky as possible.

Observatories are only an option if you live in an unattached dwelling with a backyard. If you must travel to public or semi-public locations to do your urban sky-watching, even light shields may not be practical unless you can some up with some kind of collapsible design like the PVC pipe frame idea. But there are still ways to defeat ambient light, especially if you don't mind looking a little ridiculous. How can you shield at least one eye from ambient light? With an eye-patch. Keep an eye-patch on your dominant/observing eye while you are not looking through the scope. When you're ready to view, flip the eye-patch up. Eye-patches are available from the neighborhood pharmacy/druggist.

But how do you keep the light out of your "good" eye *while* you are observing? Even with your eye pressed to the eyepiece, the glare from bright ambient lights still intrudes. Use a hood. Find a piece of black, opaque cloth—I like rip-stop nylon—and drape it over your head while you are at the eyepiece. Don't flip up your eyepatch until the hood is over your head. You will be surprised, amazed even, at how much these two simple items can do to improve your views. I guarantee that if you use an eye-patch and a hood in ambient-light-plagued areas, you will see *much* more than you otherwise would.

What if you don't like wearing an eye-patch? It's not very comfortable. And you may feel that it makes you look slightly odd (who cares?). A more comfortable alternative is a pair of red goggles (Plate 16). Obtainable from many astronomy dealers, these "light pollution goggles" are really safety glasses that have been equipped with red lenses. Use these when you're not looking through the scope, and both eyes will be protected from dark-adaptation-destroying ambient light. When you want to look through the scope, you should still, naturally, use a hood.

Red goggles, which can be easily made if you can't find them for sale, work for the same reason that red flashlights do. The rods in our eyes, the dim light receptors, are least sensitive to red light. In addition to keeping both eyes dark adapted, goggles have another advantage over an eye-patch—they preserve your 3D vision—you lose that with one eye covered. This is an important safety consideration when you have to move around. Without 3D vision, you're likely to trip over something or bump into your scope hard enough to ruin your alignment.

A possible disadvantage of these goggles is that high levels of even red light will adversely affect your dark adaptation. Accidentally looking into a streetlight with your goggles on will mean you have to start dark adaptation all over. I have also found them prone to fogging in my humid environment, despite the fact that they are provided with ventilation holes. Finally, you won't look much less ridiculous with red safety goggles on in the middle of the night than you would with a simple eyepatch (if such things matter to you).

Optimizing a Telescope for Urban Use

As delivered, your telescope may not be optimum for use in the city. The problem is that unless you take steps to prevent it, your scope will admit stray light into its optical system. No matter how well you try to shield your telescope from ambient light sources, there's still a lot of unwanted glow in the urban environment. Even if the scope is shaded from nearby streetlights, the glow from the sky may be leaking into your tube in unexpected ways. This stray light can have a very detrimental effect on your deep sky views. In my experience, eliminating it can have almost as much effect as allowing your eyes to dark adapt with hoods and eye-patches.

Dew Shields

Unless you observe in a big open space like a park or parking lot, dew is not usually a problem in the city. Nearby houses, buildings and trees tend to block your scope from the heat-sucking sky and prevent the resultant formation of dew on your lenses or mirrors. A dew shield is a must for the urban observer nevertheless. In addition to protecting your optics from dew, a dew shield can prevent oblique ambient light from entering the corrector or objective end of your refractor or SCT and ruining your images.

If you've got a refractor, it likely came already equipped with a dew shield, but that doesn't mean it's perfect. Many of those on current import refractors suffer from severe problems. Most serious is that they are too short. To be effective, a dew shield should extend in front of your objective for at least 1.5 times the lens diameter. A 6-inch refractor, for example, needs a 9-inch long dew shield. If your dew shield does not measure up, replacements are available from various sources, or you can make your own very easily. Posterboard or cardboard that's been painted flat black and sealed makes a fine dew shield. One made out of the black foam padding material sold to go under campers' sleeping bags works even better.

Another fault of the stock dew shields on refractors is their color. Look at the inside of your dew shield. Is the finish even the slightest bit shiny? If so, it is probably reflecting a lot of unwanted glare into your optical system. One solution is to paint it a very flat black. Black paint sold for use on bar-b-que grills is commonly available—at least in the U.S.—and is just right for this purpose. Even better than a new paintjob, however, is lining the dew shield with a black fabric like velvet. This can be affixed to the interior of the dew shield with contact cement, or a visit to a fabric or craft store may turn up some black self-adhesive velvet-like fabric or contact paper. Using velvet to line your dew shield will have the added benefit of absorbing some moisture if your site is prone to heavy dew.

If you're the proud new owner of a Schmidt Cassegrain telescope (SCT), your instrument came without a dew shield of any kind. There are many dew shields offered for sale to SCT users. Most have one thing in common: they are too expensive. You can easily spend 150 US$ or more on a fancy aluminum shield painted to match your telescope's OTA. If you want to spend that much money, go ahead, you won't hurt my feelings. Keep in mind, however, that one of these expensive models won't work any better than a piece of posterboard or plastic sheeting. Me? I'd rather spend my money on a new eyepiece. If you don't want to make your own dew shield, astronomy dealers also offer "flexi-shields." These are flat pieces of plastic that can be wrapped around the end of your tube and secured with Velcro to form a dew shield. These typically cost about a third as much as one of the aluminum models.

If you own a Newtonian, you don't need a dew shield, right? The mirror is at the bottom of the tube, making your entire OTA one giant dew shield. Wrong. Your telescope has its secondary mirror at the forward end of the tube where it is nearly as susceptible to stray light and dew as the lenses of refractors or SCTs. This wouldn't be a problem if Newtonians had a decent length of tube ahead of the focuser, but today's short focal length reflectors, especially the imported models, tend to mount the secondary and focuser as close to the end of the tube as possible. Do yourself a favor and extend the front of your tube at least 12 inches. This will keep stray light out and keep dew off your secondary. Use the same approach to making a tube extension as for making a dew shield—cardboard, posterboard, or plastic sheet painted flat black and sealed if necessary.

The front end of the tube is not the only place where unwanted light can enter the tube of your Newtonian. The back end, the mirror cell end, also provides a path for glare. If your OTA features an open style mirror cell—if you can look down the front of the tube and see the ground through the back of the scope—unwanted light is intruding into your scope. The sky glow reflected off the ground and back into this rear opening in the tube is enough to *substantially* degrade your images.

The solution is to construct a baffle for the back of your tube. This can be as fancy or simple as you care to make it. All you need is a round disk of some material—paper, plastic, wood, metal—with a hole cut in it slightly smaller than the diameter of your mirror. As shown in Plate 17, this baffle blocks the opening around your mirror's edge, but leaves the mirror cell open to the air, allowing it to "breathe" so that it will acclimate to external temperatures more quickly than it would if you sealed off the rear end of the tube completely. Many of the current Chinese Newtonians have a thin metal plate sealing the mirror end of the tube. This does a good job of blocking light from the ground, but should be removed and replaced with a baffle in the interests of rapid cooldown.

One final thing to look at on Newtonians is the paint job on the tube's interior. Is it really flat black? Can you see *any* reflections? Is it actually more of a dark gray than a black? If so, you'd be wise to repaint the interior of the tube if possible. Select a flat black paint and apply enough coats to completely squelch the shiny reflections (remove your optics beforehand, of course). To really suppress internal glare, mix a little sawdust in with your paint to give the finish a rough texture and further inhibit reflectivity. If painting the inside of your scope's tube does not appeal to you, there is an easier solution that is almost as effective. All you have to do is glue a piece of black velvet to the interior of your tube exactly opposite your focuser. This will at least prevent the area near the front of your tube from reflecting ambient light or sky glow directly into your eyepiece. I applied all these fixes to my 1960s vintage 4.25" Newtonian and was amazed at its improved images. No, it didn't become the equivalent of an 8-inch scope, but the sky background was noticeably darker, and deep sky objects (DSOs) stood out much better.

Using Eyepieces in the City

If you've read this far, you've gathered that I recommend using higher magnifications in the city than in the country. But what does that mean? Exactly how much magnification should you use for finding and viewing objects? When it comes to finding objects, much will depend on your scope, your site, and your finding skills. But what you want to do is find an eyepiece/scope combination that provides a reasonably dark but reasonably wide field. This is obviously a compromise. Even if you are an experienced "star hopper" able to locate any object in seconds under dark skies, the lack of guide stars in bright city skies will mean that you will not be as accurate—you'll have to hunt around. Obviously, a low power eyepiece, a 35-mm or 40-mm wide field design would be a big help, shortening your search. Unfortunately, at low powers, you may never find your objects. The sky background is bright enough to obliterate a dim galaxy, for example.

Settling on a finding eyepiece is a matter of experimentation. If you've got a good collection of oculars, train your scope on a fairly challenging medium-sized DSO (M51, the Whirlpool Galaxy, is a good one for most urban observers using 8-inch and larger telescopes). Keep lowering your magnification by going to successively longer focal length eyepieces until you find one that allows you to *barely* discern that the galaxy is in your field. Don't worry about details, you just want to be able to see that the galaxy is there. The ocular that provides this magnification will be your finding eyepiece. If you are hunting easier objects—open star clusters rather than galaxies and nebulae—you can lower your power to make things easier.

Even if you have a go-to scope, you'll want to use as wide a finding eyepiece as practical for your scope. Current go-to-equipped instruments are surprisingly accurate when carefully aligned, but, as was mentioned earlier, you cannot always rely on them to always put an object in the field of a medium power eyepiece. The widest field eyepiece you can use effectively in the city will make object location with a go-to scope much quicker if your target doesn't appear in the field at the end of the slew. You won't have to search around using your hand controller to slew the scope at low speed.

Once you've got a target object in view, how much magnification should you use for observing in light-polluted areas? Like the choice of the finding eyepiece, this is dependent on several factors: scope, sky, object type, and observer preference. In general, try to use as high a magnification as possible that still frames the object well—lets you see as much of it at one time as you desire—and provides a comfortable view.

Once again I'll emphasize: deep sky observers in the city *or* in the country tend to use less magnification than is optimum. The human eye is capable of making out details more easily in a large image than a small one. You don't, of course, want to use so much magnification that the object becomes dim to invisibility. You want to find a power that darkens the sky background enough to provide good contrast while keeping the object in view as bright as is possible. Experimentation will show you what's right for you and your scope, but I find myself most often using about 100–150× as an everyday viewing magnification, and will often go considerably higher—to 200× and above—for small galaxies and planetary nebulae. This is with my 8-inch and larger scopes. For small apertures, you may have to scale back these magnification values somewhat.

Binoviewers

This subject could easily have gone into the Accessories chapter, but binocular viewers for telescopes are such a specialized piece of equipment that I thought they'd be better off here. As shown in Plate 18, a binoviewer is a device that is inserted into your star diagonal (refractor or CAT scope) or focuser (Newtonian), and which uses a system of prisms to divert the light from your telescope's optical system into two separate eyepieces. What good is this? All day long you use *two eyes*, but when night comes and you drag out the telescope, you use *one eye* to view the heavens. Viewing with one eye is unnatural and uncomfortable whether you are in the dark country or bright city. Some people can train themselves to leave their unused eye open while viewing through a telescope's eyepiece, and that helps some, but is very hard for most observers to do in the less than dark environment of the city. Most amateur just squint painfully. Binoviewers are offered as a remedy for this "wasted eye syndrome," and makers and fans of these accessories swear that you can see more with two eyes than you can with one. I'm always looking for ways to squeeze every last photon out of our city skies, so I decided to see what a binoviewer could do for the urban observer.

The U.S. company Denkmeier Optical was kind enough to loan me one of their binoviewers for evaluation purposes, and I found it to be a very well constructed, high quality piece of gear. I located a couple of identical 25-mm eyepieces to use in the Denkmeier and hit the backyard for an evening of comparative viewing. What I found was that the binoviewer *did indeed* reveal more details in any DSO I put into the field of view. The image in the binoviewer *was* slightly dimmer than it was in a single eyepiece, but, despite this, I always thought DSOs looked better with the binoviewer than without. The effect is hard to explain, but I suspect that the fact that I was more comfortable—no squinting one of my eyes—had a lot to do with me being able to see more. Let me add that in the excellent binoviewer I tested, the combined image was not *that much* dimmer than with single eyepiece, "Cyclops style" viewing, as the binoviewing fans say. I had, for example, the best view of M37, the marvelous open cluster in Auriga, I've had in a long time. *A binoviewer helps in the city.*

Another interesting and pleasant effect of using a binoviewer is a pseudo three-dimensional (3-D) effect. Given the distance to celestial objects and the very small separation between your eyes, there is no way that you can see a DSO in 3-D as you would earthly objects. But your brain refuses to believe that. You are using two eyes, so you *must* be seeing depth. This insistence by my brain that I must be seeing in three dimensions was particularly striking with M42, the Orion Nebula, with the Denkmeier. The nebula seemed to be in the mid-ground, while some stars, the brighter ones, appeared in the foreground. Dimmer sparklers formed the "background." Completely false, of course, but a beautiful and moving effect nevertheless.

Binoviewers are *not* for everyone, however. While they offer improved images in the city and in the country—I'm convinced of that—you have to be willing to pay a premium price for this admittedly relatively small improvement. Good quality binoviewers are priced at around 600–1,000 US$ and are sold for comparable or higher prices in the UK and Europe. Believe me, you will want the highest quality binoviewer you can get. They must be precisely aligned and mechanically stable. The slightest miscollimation of a binoviewer's prisms will result in headaches and eyestrain at best and two separate images that cannot be merged into one at worst.

Your spending won't be complete when you've purchased the binoviewer, either. You'll need eyepieces for the thing. That means you will have to buy identical eyepieces for every focal length you want to use. Often you can't just buy duplicates of those you already own, either. As time passes, manufacturers change the sources and specifications of their oculars. For use in a binoviewer, the two eyepieces must be as identical as possible. If they are not, you may very well run into problems with merging images. Even if you're content to stick with inexpensive Plossls, at least for a while, setting up a binoviewer with a minimum complement of maybe three sets of eyepieces means spending real money.

The binoviewer will need a home, too, a secure home if you use it in a refractor or SCT. By "home" I mean a star diagonal. A binoviewer is a heavy piece of equipment and using one with a standard 1.25-inch diagonal may be a recipe for disaster. I once saw an expensive binoviewer drop to the ground when the barrel of the 1.25-inch star diagonal it was riding in rotated and *unscrewed* under the weight of the viewer, and the setscrew holding the binoviewer in place let go. Plan on purchasing a heavy duty 2-inch star diagonal to accommodate a binoviewer. Most binoviewers have 1.25-inch barrels, and only accommodate 1.25-inch eyepieces, but 2-inch format star diagonals are heavier duty, usually, than 1.25-inch models, and are better suited to holding a heavy accessory like a binoviewer. If possible, purchase a 2-inch diagonal that uses a compression ring to hold eyepieces in place. A compression ring not only prevents marring of the binoviewer barrel, which can be caused by tightening setscrews tightly enough to hold the bino in place, it holds this heavy accessory in place more securely.

You may even have to modify your telescope before you can use a binoviewer. Most models require a considerable amount of extra inward focus due to their system of light-folding prisms and the resulting longer light path before the image reaches the eyepieces. A moving mirror focusing scope, a Schmidt Cassegrain or Maksutov Cassegrain, won't have a problem. Some refractors and almost all Newtonians, however, will. At a minimum, you may have to insert a "relay lens" supplied by the binoviewer manufacturer between the viewer and the scope. These lenses will allow the binoviewer to reach focus, but will usually act as barlow lenses, meaning wide fields are impossible to achieve. For some scopes, even a relay lens may not work. You may have to move your Newtonian's primary mirror or shorten your refractor's tube.

Sounds like a lot of expense and trouble just to be able to use two eyes, but, in my judgment, you may still want to consider a binoviewer. I was skeptical about these devices, but after using one for a few months, I became a convert. They really do improve the observing experience in the city. The only case where I was disappointed was in objects that were at the very edge of detection in a single eyepiece. These were sometimes invisible in the binoviewer, but were no great loss. In addition, if you like to look at the Moon and planets, binoviewers can provide tremendous views, putting single eyepiece set-ups to shame.

Finding Objects in the City

All the fancy telescopes, eyepieces, and binoviewers in the world aren't worth anything if you can't find objects to view. Locating objects, dim DSOs not visible in a finderscope, is a frustrating experience for beginners under the best conditions, and in the city even experienced observers may have a hard time. Yes, those galaxies, nebulae, and star clusters *are* there, many of them, anyway, despite your sodium-pink skies, but they can be difficult to land on due to a lack of visible stars to guide you to them. But I guarantee you can find any object visible in your skies and your aperture with relative ease by using one of the following methods or a combination of them.

Brighter Objects and Richer Star Fields: Star Hopping

Star hopping is the normal method amateur astronomers use to find objects if they don't have or want to use setting circles or go-to telescopes. Star hopping is actually something of a misnomer in my opinion. What you are actually doing is making *patterns* in the stars. Say, for example, I want to find the wonderful little star cluster NGC 457. This group, known as the "ET" or "Owl" cluster due to its stick figure shape, is a good object to hop to in the city since it's located among the bright and prominent stars of Cassiopeia. How do you capture ET? Take a look at Figure 4.1.

You'll see that the cluster forms a triangle with two stars in Cassiopeia's "W," Delta and Gamma. I've indicated this with the dashed lines I've superimposed on the chart. Move your scope so that it's approximately on the place in the sky indicated and, with a little hunting around you'll have ET in your field. Do the same sort of thing with other objects. NGC 129 is about halfway along a line drawn between Gamma and Beta. NGC 663 is at the apex of the triangle formed with Epsilon and Delta. You can do this all over the sky, forming triangles, lines, and other patterns to lead you to

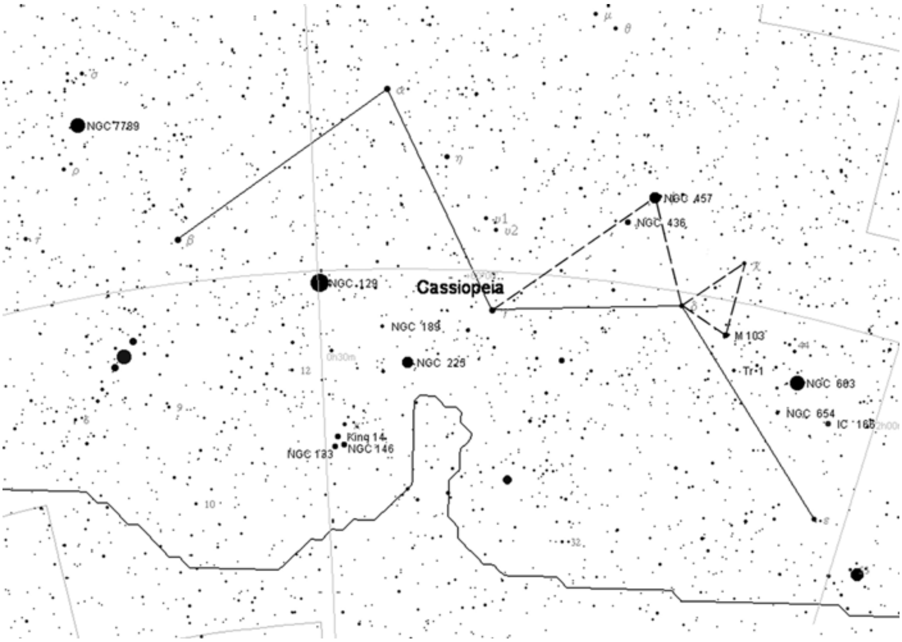

Figure 4.1. Star hopping in Cassiopeia.

objects. This works well, however, *only* if you've got enough bright stars to easily form patterns and if the object you're hunting is bright enough to show up easily with a little scanning around.

Dimmer Objects: Eyepiece Hopping

What if there aren't any bright stars in the neighborhood? Or what if the object is dim enough that you need to be more precise when looking for it—if it'll be easy to pass over while quickly slewing around? In these cases, we'll use Method 2, Eyepiece Hopping. A good area for this technique, as was mentioned in the preceding chapter, is in Virgo. Again, there are dozens of galaxies visible here from even very poor skies in medium-aperture telescopes. But if your conditions are as bad as mine, there'll be few stars visible, even in a large finder, far too few to allow you to hunt down the dim DSOs lurking there.

To begin eyepiece hopping to a target, you will have to locate a starting place by other means. This may be by star hopping—usually you can find a few prominent stars somewhere close to the area of interest to use as a jumping-off point—or setting circles. Figure 4.2 is a medium wide-angle chart of Virgo, with our starting point indicated by the eyepiece field circle labeled "1." One of the few striking asterisms visible in this area of my sky is the little Y-or arrow shaped figure of magnitude 4–6 stars near the field circle 1 is centered on. This star pattern, which includes 5th

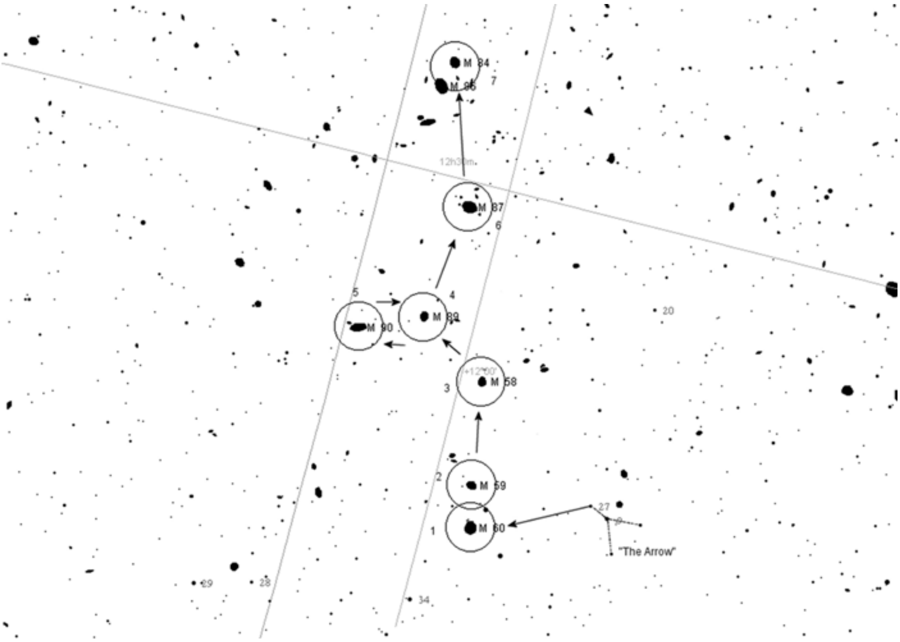

Figure 4.2. An eyepiece hop through Virgo.

magnitude Rho virginis, is easily identifiable in a 50-mm finder, and is a quick hop from bright Epsilon Virginis. Once you've got the "Y" in your eyepiece, your work is really over. If you're careful in moving your telescope, you can enjoy galaxies all night long without using your finder again.

How? Refer to Figure 4.2 again. Once you're centered on the "Y," insert an eyepiece that provides good contrast while yielding as wide a field as possible. Use your judgment and your familiarity with your own skies to decide what to use. What worked well for me was a 22-mm Panoptic in my 11-inch $f/10$ SCT. In my 12.5-inch $f/4.8$ Newtonian, a 12-mm Nagler wide-field eyepiece worked splendidly. When you're ready, while looking through the eyepiece at the stars of our little Y, move Northwest to land on the field labeled "1." How much you move depends on your scope and your eyepiece. My SCT setup meant that I had to move about 1.5 fields to the Northwest to achieve the $45'$ of distance I needed to travel with my $0.5°$ true field eyepiece, a short enough hop to make it easy to be precise. Once you're there, look carefully. The Messier galaxy M60 will be glowing in the center of the eyepiece. What if you moved a little more to the North than you should have? That will land you on a different galaxy, M59 instead, but your mistake should be obvious when you compare the field stars to those visible in your scope.

Naturally, you'll have to spend some time planning your routes, designing them for your scopes and eyepieces, but this method is very worthwhile, and will allow you to see more in star-barren areas of the sky like Virgo than you ever thought possible (I've also used eyepiece hopping to very good effect in and around the bowl of the

Dipper/Plough). You can design eyepiece hopping charts using a detailed star atlas like *Uranometria 2000* and a pencil and compass, but I find that a computer program makes the process incredibly easier. The chart in Figure 4.2, like all the charts in this book, is based on originals done with Patrick Chevalley's free program, *Cartes du Ciel*. *Cartes* allows you to plot eyepiece field circles exactly of the correct size and orientation for a given scope and eyepiece combination, meaning that it will be clear how far you need to move to get to the next object's field. One word of advice: make your charts in a larger scale than I have in Figure 4.2, maybe placing only two or three eyepiece fields per page in order to make it easier to verify patterns of field stars to make sure you're in the right place.

The Setting Circle Alternative

When I was a young man with a new 3-inch telescope on an alt-azimuth mounting, I dreamed of getting my hands on an equatorial mount equipped with *setting circles*. Analog setting circles (Plate 19) are graduated dials, one for each axis of the telescope, with the declination circle being marked in degrees and the right ascension (RA) circle labeled with hours and minutes. The idea is simple; you move the telescope until pointers on the setting circles indicate the proper values of RA and declination for the object you're seeking (obtained from a book or chart). When the right values are dialed-in, the object of your desire should be in the telescope's field. Wow! I dreamed of cruising through the Messier list and beyond with ease, *dialing my way* across the heavens to every imaginable DSO, viewing galaxy after galaxy effortlessly. No more finders, no more star charts.

When I finally obtained a decent German equatorial with a pair of setting circles, the truth turned out to be less glamorous than the dream. For one thing, a couple of years with an alt-azimuth mounted scope had made me a proficient star hopper at age 12. I found it easy enough to find almost any object I wanted with the aid my star atlas and finder, so the effort required to learn the use of setting circles didn't seem as worthwhile. When I finally got around to figuring out how to use them, they lost even more of their appeal. Try as I might, I just couldn't locate objects with my circles. I was lucky to even get a target in the field of my finder. I forgot about setting circles and didn't use them again until I began teaching astronomy at a university and was tasked with showing students the ins and outs of analog setting circles.

Surprisingly, despite my less than happy memories of setting circles, I found they can work very well if some conditions are met. The first is that the circles must be large enough. Large diameter setting circles mean greater accuracy. On most small imported German equatorial mountings (GEMs), they are far too small to be accurate enough to put an object in the eyepiece of the main scope. For accuracy, you need something about the size of the RA circle on modern fork-mounted SCTs (8 inches in diameter). Unfortunately for SCT users, the declination circles on these scopes approach too small at about 4 inches, but even that is much better than what you'll see on most imported mountings.

Accurate setting circle *calibration* is another requirement. Declination circles should be properly set up at the factory, but they do occasionally require readjustment. When a fork-mounted scope's tube is parallel to the fork arms (determined by the use of a bubble level) or a GEM's tube is precisely parallel to the RA shaft, the declination circle must read *exactly* 90°. The mount's RA circle must be calibrated every single night, as it will lose its alignment as soon as your clock drive is turned off—assuming it is driven by the scope motor, an important plus for any scope. A "driven" RA circle maintains the same reading as the scope moves to track the sky. An undriven circle slowly loses accuracy, becoming a little more "off" as the scope tracks. If the RA circle is not driven, you'll have to continually reset it all night long. To calibrate the RA circle, driven or not, place a star of known right ascension in the field of a high-power eyepiece and adjust the circle till it reads the RA value of the star.

The final, and possibly most critical, requirement for satisfactory setting circle performance is accurate polar alignment. In order to locate objects, especially those far from the star you use to align the RA circle, your scope's RA axis must be pointed very close to the true celestial pole. The better your polar alignment, the better your results will be. Of course, you reach a point of diminishing returns, and I don't feel it's necessary to do a photographic-precision drift alignment to use setting circles. On the other hand, just pointing the scope's RA axis at Polaris will rarely yield satisfying results. A good compromise is a polar alignment scope. Either a bore-scope built into a GEM's right ascension axis, or, for a fork-mount scope, a standard finder with a special polar alignment reticle. These devices will yield an alignment "good enough" for setting circle usage without requiring so much time for an alignment that you'll be reluctant to do it.

By scrupulously observing all the above requirements, I've had very good success with my SCTs' circles. I don't always get an object in the field of even a low-power/wide-field eyepiece, but the quarry I'm hunting is usually within half a degree of where I land, and all I have to do is to carefully and slowly slew around a little bit to move it into my field.

What if you're the owner of a mount with too small circles? Or your skies are so bad that it would be a big help to get dim objects in the field of a low-power eyepiece every time? If an object is on the very limit of visibility in your skies, hunting around blindly over comparatively large areas may not always yield results. If you *know* the object is in the field of your low-power eyepiece, you can up the power to increase your contrast, and usually capture it with just a little hunting around. To get this increased accuracy, though, it's necessary to forget analog circles and go digital.

Digital Setting Circles

When digital setting circles (DSCs) first became popular with amateurs in the 1980s, that's all they were, "digital setting circles." They merely replaced your analog-readout circles with a digital display. Your scope had to be precisely polar aligned to make use of them, and, while accuracy may have been slightly better than with analog circles due to their finer readouts—they solved the "too small circle" problem—accuracy was generally similar to what a careful user of quality analog circles could achieve. Then the computer revolution hit amateur astronomy full-force.

By the early 1990s, DSCs had become real computers and quickly made analog circles obsolete for observers seeking high accuracy. The most important advance was that the new DSCs made precise polar alignment less important. Many DSC computers, then and now, work better with an accurately polar-aligned telescope, but can deliver very good accuracy with nonpolar aligned instruments, including Dobsonians. About this same time, DSCs also began to offer large internal databases of objects. You no longer had to look up coordinates and match them to the DSC display. Want to go to M13? The readout of the newer circles indicates which way to move the telescope and tells you when to stop.

An example of a modern digital-setting circle computer is shown in Plate 20. This is the Argo Navis DSC system, which offers many of the same features as the most advanced go-to telescopes. A unit like the Argo Navis can actually make a "full go-to" instrument unnecessary for many observers.

What can DSCs do for you? With an equatorial telescope, they can deliver consistent 0.5° accuracy across the sky, putting objects in the field of a low-power eyepiece every time. They can do just about as well with a Dobsonian, assuming that its rocker box is solidly built and square—"orthogonal." In order to achieve this accuracy, a few conditions do have to be met. The encoders, the little optical sensor units that attach to each axis of the mount and tell the computer where it's going and how fast, must be carefully installed. If the shafts of these units are not firmly connected to the scope mount (by means of gears or belts, usually) the encoders will slip and the computer will be misinformed about its position. Care must be taken with the two alignment stars used to set the DSCs up at the beginning of a session, too. Follow instructions given by the DSC maker about choosing stars (usually you'll want stars about 90° apart in the sky, no more, no less), and use a high-power eyepiece when performing the alignment.

Are DSCs a good buy for the urban observer? Maybe. If you've already got a telescope that's well suited for city lights observing, the answer is a definite "yes." Though top of the line DSCs are relatively expensive (around 500 dollars or pounds), they can go a long, long way to making your viewing more productive and more fun. On the other hand, if you don't yet own an instrument suitable for city use, you might want to consider a go-to telescope instead.

Go-To for the Urban Astronomer

Go-to telescopes, computerized scopes that point themselves to desired objects at the press of a few buttons, have been sold to amateurs for almost 20 years now. Celestron in the U.S. offered the first mass-produced go-to SCTs, the Compustars, in the late 1980s, and its competitor, Meade, brought-out the first "popularly priced" computerized SCTs, the LX200s, in 1992. Go-to telescopes have come a long way in 20 years. The initial scopes were not really more accurate than DSCs, had small object libraries, and were offered only in the SCT optical design. Now, go-to scopes, even those with rather large apertures, cost far less in real currency than the early models did. They are also equipped with libraries of DSOs ranging up to 100,000 objects (though you're unlikely to see many of these with an 8- or 10-inch telescope). Go-to has also moved far beyond SCTs. The go-to Schmidt is still probably the most common computerized scope, but it is not at all uncommon to see an APO refractor or Newtonian pointing itself at DSOs anymore.

Should you buy a go-to telescope for city observing? In practical terms, in terms of reliability and utility, the answer is YES. Today's go-to instruments are considerably more reliable than the old Compustars or the early LX200s. Most importantly, they are a boon for observers working under light-polluted skies. If you can see two alignment stars, you can get any object you choose in the field of your scope. Being able to see the DSO you are after is not always a given, but it will be there. Current go-to telescopes are usually considerably more accurate than DSCs, with pointing errors often being measured in just a few arc *minutes*. My current personal scope, a Celestron Nexstar 11 GPS, will, for example, consistently put anything I ask for in the field of a TeleVue Nagler 12-mm at 220×, which pulls many, many objects out of the bright sky. I think go-to is the greatest thing to ever hit urban astronomy.

Not everybody thinks go-to is such a good thing, however. If you read the Internet astronomy message boards or hvae listened in on a heated conversation or two at your local astronomy club, you're aware that some observers are opposed to go-to on *philosophical* grounds. They claim that by automating the finding process amateur astronomers, particularly new amateur astronomers, miss out on the fun that comes with learning the constellations and star hopping. I wish some of these die-hard traditionalists would pay a visit to my backyard on a spring night and have some "fun" star hopping through Virgo. I'm willing to bet they'd lose heart in that bright desert soon enough and make friends with my Nexstar 11.

I do think amateurs should learn the constellations as a matter of personal pride, but telling an urban observer to star hop doesn't have the desired result of making him or her a better observer. It often just means she'll drop out of the hobby due to the difficulty inherent in star hopping in city skies and the boredom of not seeing much. *If you observe in the city, get a go-to telescope if at all possible.*

A question I'm often asked is, "Can I retrofit my manual telescope for go-to?" The answer is "maybe." If you have a fork-mounted telescope—SCT, MCT, or other—the answer is no. Installing go-to on a fork would require major and extensive modifications. Talented individuals have done custom go-to mods for their fork-mounted scopes, but this task is far beyond most of us. If you have a German mount, though, the answer is a qualified "yes." Various manufacturers offer go-to drives for a variety of GEMs, and especially the Japanese Vixen Great and Super Polaris and their "clones," the Chinese EQ4s and CG5s. The Losmandy G11 and GM8 GEMs can also be given go-to capabilities.

Most of these add-on go-to units, which are available from a variety of manufacturers including Vixen, work very well. Go-to German mounts also provide an upgrade path for fork-mounted SCT owners. You can't equip the fork for go-to, but if you have a good optical tube, you can remove it from the fork, put it on a go-to GEM and keep on truckin'!

The scope is ready outside, you've gathered your accessories, and are prepared for an evening of city observing. What do you observe? Which objects look best in the city? Which are impossible? How do you tell the difference? That's the subject of the following Chapter 5.