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The Urban Astronomer's Guide

A Walking Tour of the Cosmos for City Sky Watchers

Rod Mollise

Springer

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Mobile, AL, USA

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Introduction

The Urban Astronomer's Guide is the result of a crazy idea for a book that came to me nearly twenty years ago. I knew deep sky objects—nebulae, star clusters, and galaxies—could be seen from the city. Plenty of amateur astronomers were braving countless streetlights in search of distant marvels. But there was little written information available on viewing the deep sky from urban and heavily light-polluted suburban locations. The only mention of the subject I found in astronomy books and magazines was the stern warning that it was impossible to get a good look at anything other than the Moon and planets from urban locales. I knew this wasn't true—I'd observed the entire Messier list from my bright backyard and had a lot of fun doing it. I was sure many more amateur astronomers "trapped" amid city lights would also love to see deep sky wonders from home—if only they had a little information and encouragement. Solution? The book you hold in your hands.

I spent many, many hours observing the objects that form the sky tours included in this guide. But that was the enjoyable part of the project. The hard work was done by my friend and fellow observer, Pat Rochford, and by my dear wife, Dorothy. They didn't share much of the observing fun; instead they devoted themselves to the tasks of checking the manuscript, and, most importantly, providing the encouragement I needed to keep going with what some people told me was an "impossible" concept for a book. Thanks are also due—in spades—to John Watson. Just when I was ready to toss this idea aside, he, like Pat and Dorothy, kept me on track. Dorothy, Pat, and John—this one is for you.

Rod Mollise
Selma Street
Summer, 2005

PART I

Telescopes and Techniques

CHAPTER ONE

The Whys and Hows of Urban Observing

Have you gone out into your backyard or garden and looked up at the night sky lately? If you're a seasoned amateur astronomer living in the city, especially an astronomer interested in the deep sky, the universe of objects beyond the Solar System, you probably haven't. The conventional wisdom is that the quarry deep sky observers hunt—star clusters, galaxies, and nebulae—doesn't show up well, or at all, from the typical sodium-streetlight-pink urban sky. Every veteran city-bound amateur probably spent some time observing from home as a novice when every night was an adventure and not a single clear evening was to be wasted. But with experience and a growing orientation toward deep space, most city dwelling astronomers eventually desert the backyard for occasional trips to darker locales—an astronomy club "dark site," a friend's vacation home or farm, or an organized star party.

Trips to dark sites are great, but wouldn't you like to get out with your wonderful telescope more often? That's what this book is all about. Whether you're a novice amateur or a deep sky veteran, it will show you how to enjoy *night after night* of wonderful sights from the comfort of home. There's an amazing amount to be seen, even under the brightest skies. What I am going to do is take you on a walking tour of the cosmos. We'll travel from depressing city lights to the wonders of deep space. You'll learn what you need to pack for these hikes, what's to be seen out there, and how best to see it. The bulk of the book consists of ready-made seasonal tours of the heavens, but you'll also learn how to plan your own night sky journeys. Before considering the "how" of urban amateur astronomy, though, let's talk more about the "why."

Yes, observing from perfect country skies is wonderful, but an emphasis on dark site observing comes at a price for the urban-dwelling amateur: if you rely only on these opportunities, you'll usually wind-up observing once a month—if that frequently. "Once a month" is a far cry from the "every clear night" of novice days, but for today's amateur that's often as good as it gets. Organized club star parties are usually confined to weekends closest to the new Moon, and, while an individual with a personal dark site can theoretically get out deep sky observing more often than that, the facts of modern life—two career families and long workdays—tend to rein things back to once-a-month. Distance is another complication that cuts the frequency of observing runs for the urban astronomer. Getting to dark skies means driving 40–60 miles from the center of even a medium sized city. If you have to travel an hour or two, set up the scope, and then allow time for tearing things down, packing and returning home, you are not going to be doing much weeknight observing. This once a month syndrome (which may be reduced to "every couple of months" due to poor weather) means that the urban deep sky observer is usually badly out of practice.

Being lost in space is a feeling well known to the city-based astronomer. It's been a couple of months since you were last out observing at the club observatory, and, even then, you didn't see much since the New Moon came on a partly cloudy evening. Tonight is different. You're at the Texas Star Party, your yearly getaway under the superbly bright stars and dark skies of the Southwest U.S. desert. Not a light in sight. Velvety blackness and stars everywhere. And there you stand, not quite feeling in harmony with the cosmos. The telescope that was so easy to assemble in your active novice days now seems slightly puzzling. Where do you insert the bolts that attach the tripod to the mount? What was that quick-and-accurate polar alignment method that once seemed so easy? Naturally, the constellations, with their scads of stars visible in dark skies, look a little unfamiliar, but getting oriented would be easier if you at least remembered which *bright* star was which. If that weren't bad enough, when the telescope is finally assembled and aligned, objects that once looked spectacular don't seem to show as much detail as they did in the past. You almost feel as if you've forgotten how to observe. You have.

Sir William Herschel, arguably the greatest amateur astronomer of all time and a professional musician, often likened observing with a telescope to playing a musical instrument, and was of the opinion that astronomical observing, like music, requires constant practice. If you've experienced the above lost in space feeling, you know Sir William was right. Observing is a complex series of tasks, from gathering equipment for the evening's run, to developing a list of observing targets, to getting the best view of a galaxy. Without constant repetition these skills grow rusty. How good are you at any complicated task you only perform once every month or two?

What's the answer? It would be nice if we all enjoyed dark skies from home, but light pollution is not going away tomorrow. Many dedicated amateur and professional astronomers are working to reduce this curse of modern times, but it's unlikely that the average urban amateur's skies are going to get better any time soon. The answer for the city observer is simple and lies close at hand: despite bright skies, observe every clear night. From the backyard, the rooftop, the secure park, the science museum parking lot, or any place in the city where there's an open view of the sky from safe surroundings.

What Can You See from the City?

"Well, that's OK for the Solar System boys. They can do well downtown. You don't need dark skies to view Jupiter, Saturn, or the Moon, but I don't care about that stuff.

I want to observe the deep sky, and you *have* to have a dark site to see *anything* beyond a few of the very brightest objects." Wrong. There's a *lot* to be seen by the patient, educated deep-sky observer from almost any urban site, including:

- The entire Messier list, even M74, M33, M76, and M97, the supposed "hard ones."
- Many NGC objects, and not just open star clusters, though you can feast on as many of those as you desire.
- Supernovae burning in the hearts of distant galaxies.
- The beauty of the classical constellations in their stately march across the sky as the seasons change.
- The comings and goings of those intergalactic tramps, the comets.
- Hordes of asteroids tracing their lonely paths through the Solar System.
- The animals that form our urban ecosystem and survive unnoticed under the foot of Man.
- The looks of wonder on the faces of family, neighbors, and friends as you show them sky marvels from the friendly surroundings of home.

Come join me on a typical city evening's observing adventure. Tonight, my instrument of choice is my "big" scope, an inexpensive Meade 12.5-inch Dobsonian reflector. Depending on my goals, I might have chosen an 80-mm short-tube refractor, a Celestron Nexstar 11 Schmidt Cassegrain telescope (SCT), or just a pair of binoculars. On this evening the 12.5-inch scope is appropriate because, in addition to observing some Messier galaxies, I'll be searching for a supernova, an aged and obese star that's ending its life in a spectacular explosion near the heart of a distant galaxy. The 12.5-inch telescope provides generous aperture for supernova hunting, and it is also surprisingly easy to set up. I carry its "rocker-box" mount outside, plunk it down, manhandle the tube out the back door and onto the rocker box and I'm ready to go.

With the scope assembled, I turn to the evening's observing list. Some fellow amateurs find it amusing that I go to the trouble of drawing up detailed lists and charts for an informal peek at the sky from my backyard. But, in truth, detailed planning is probably more important for the urban astronomer than for those blessed with dark skies. If the sky is clear, country astronomers can turn their scopes to any quarter of the heavens and be rewarded. We urban observers have to be more discriminating. Before setting the scope up, I had a look at the virtual sky with the aid of *Skytools 2*, a computerized astronomy planning and charting program that runs on my PC. I used it to help me select interesting objects nearing the meridian for my date and time—objects as high in the sky as they'd ever get for my location. This selection process allows me to escape some of the worst effects of light pollution near the horizons.

As the sky darkens and enfolds me and my beloved telescope, I begin to get into the rhythm of sky and land. Sure, if I concentrate I can hear traffic on the busy thoroughfare just two blocks away, but my mind filters that out. I only hear the comforting chirp of crickets, smell the spring smells of garden greenery on the warm air, and see the inviting glimmer of the first stars to grace the evening sky. The sky itself? Oh, it's not pristine. Far from it. The horizons are ringed by the gaudy pink of countless sodium arc streetlights. Even on a crisp winter night the short exposure of Orion in Plate 1 is obviously fogged due to heavy sky glow. Conditions are even worse tonight in the hazy atmosphere of spring. But the great constellation Leo is riding high tonight. His sickle, hindquarters, and even a few of his dimmer stars sparkle into view as the day ends. These are not the skies of a southwestern desert, never have been, never will be, but they are still beautiful in their own right.

Soaking-up ambience is nice, but I am hungry for the deep sky. Referring to my charts and using the large-aperture finder mounted on my Dobsonian, I "star-hop" to my first target, galaxy Ml05. After just a little hunting around—I'm very familiar with the area, since my backyard site allows me to get out every clear spring night and tour Leo and Virgo—I have M105, an elliptical galaxy, in the field of my eyepiece. Once I have it centered I increase my magnification a little to provide a pleasing view and just stand and look for a few minutes. Before I began urban observing, I would have doubted that M105 would even be visible from the city. But there it is. It is not only visible but "bright" and displaying as much form and substance as any elliptical galaxy can, a bright core surrounded by an extended, circular envelope of nebulosity. There's more. As I continue to stare at the field, two more galaxies pop into view. Little NGC smudges, companions to bright M105.

After spending an hour hopping from galaxy to galaxy across the Lion, I remember my "special object" for the evening, a supernova that has appeared in galaxy NGC 3877. Not knowing quite what to expect, I move the scope to the location in Ursa Major where this nondescript spiral lurks. I've never looked at it before, but my big finder and the wide-field eyepiece in the main scope help me pin it down without too much trouble, despite the fact that it lies in an area of my sky that is almost completely barren of stars to the naked eye. The galaxy is not much to look at (and probably wouldn't be much even under dark skies), but it's detectable in a medium-power eyepiece.

And there's the supernova, a fiery speck close to NGC 3877's center that gives the galaxy a seeming "double nucleus." For a moment I'm a little awestruck. This isn't the first supernova I've seen, but the thought of the significance of the photons pouring into my eye from this ancient, violent event never fails to evoke wonder. Well I know that I probably wouldn't have seen it at all if I'd disdained the backyard. By the time I could have organized a trip to a dark site—a couple of weeks, probably—the supernova would likely have dimmed past the point where I could detect it from the darkest location.

Supernova and host galaxy sketched on a log sheet and marveled over for quite some time, I return to Leo. I know I haven't exhausted all his wonders, not by a long shot. Not all my targets are easy from the city, and I have failures as well as successes, but instead of bemoaning my horrible sky, I simply resolve to revisit the "not-seens" again on a slightly better night.

As the evening grows older, I see the lights in the house begin to wink off as my wife prepares our home for deep night. The door opens and she walks lightly into the backyard, wanting to spend a little time with me as the day enters its dark, quiet reaches. I turn the scope back to the supernova, and we admire it together, wondering softly aloud. Then we step back from the telescope and just contemplate the eternal stars together. Neither of us notices the ugly light pollution, really, we simply appreciate the beauty we're given in silence until we're startled by the "WHOOO!" of the neighborhood owl who's winged in, wondering what we're doing—or maybe just looking for a stray mouse.

Beyond the many sky marvels I find on every city night, there are the practical pleasures of using an urban site. When it grows late and I know it's time to call it a night, it takes all of 10 minutes to carry scope and accessories back into the house and be drinking a whiskey, ruminating on the sights I've seen over the last several hours. The ease with which I can set up and teardown means I'm not only anxious, but *eager* to observe on every clear night. While the once-a-month dark-site-only observers are complaining about what a terrible spring it's been weather-wise, I'm remembering the *many* nights I've spent with the deep marvels of Virgo and Leo.

Finding an Urban Observing Site

Before you can start taking advantage of urban observing, you've got to have an observing site. If you live in a detached home with even a small front or back yard/garden, your problems are over. Like me, you just trot the scope out the door and start having fun. If you live in an apartment or townhouse, however, the solution is not quite so simple. One alternative for the apartment resident is the roof. Often the roof of an apartment building is accessible by an elevator or stairs if you're lucky, or a ladder and hatch arrangement if you're not so lucky. If you're faced with the latter, the best you can hope to do equipment-wise is a small refractor or binoculars—you're not going to lug a 16-inch Newtonian monster of a telescope up a ladder. Even if all you can use on the roof is your Short Tube 80-mm refractor, though, the experience is usually going to be a nice one.

"Up on the rooftop" you've likely got fairly unobstructed horizons, and, assuming the roof area is not lit by the all too common mercury-vapor security light, you may find a little relief from light-pollution up there as well. At least you'll be able to avoid a lot of the ambient light at street-level. Naturally, before you start using the roof it would be wise to inquire as to the feasibility of doing so with your building superintendent. You don't want to suffer the ignominious fate of being locked out while up on the roof some night, and you certainly don't want to do something that would endanger your lease.

What if the roof is inaccessible or otherwise impractical for use as an observing platform? In some areas of the world, especially the older parts of larger European cities, flat-roofed apartment houses are uncommon. Or what if you live in a townhouse or other attached single family dwelling without a usable roof area *or* a yard? If you have a balcony, that will provide you with a usable, albeit cramped and limited (in the amount of sky you can see), observing platform. Actually, you'll be surprised at how much you'll see, even in the limited expanse of sky offered by a balcony if you're patient and observe at various hours of the evening as the seasons progress. But you may want to search for an alternate site, one you can use on the occasions when you need to see a part of the sky invisible from your balcony roost.

If you have neither usable roof nor garden and no balcony either, your best bet may be to discuss your problem with the local astronomy club. Chances are, they know of safe and convenient areas where you can observe in town. Even the largest and most light-polluted metropolises have active astronomy clubs whose members observe from within the city limits at least part of the time.

What are possible observing locations other than home? A school or science museum with a flat roof or secure parking lot or other open area is a good alternative. Frequently, these institutions will be willing to provide you with observing space if you'll agree to help them with public outreach astronomy activities once in a while, especially if you approach them with your astronomy club friends as an organized group. The problem here is that most of the open areas possessed by city schools, museums, and similar organizations will be heavily lighted with the brightest sodium or mercury vapor lights money can buy. Sometimes these can be turned off, often not. Even in the case of constantly burning security lights, though, you will probably find at least one shadowed corner where you can observe profitably.

Parks and other public areas are another possibility, but a couple of difficulties exist with these. Most limiting will be the city's rules concerning your use of these locations. In my town, for example, there's a beautiful and safe municipal park that would provide a good observing venue. Unfortunately, despite few demonstrable problems with anybody in the park over the years, the City Fathers in their wisdom have seen fit to close it at sundown, pretty much eliminating it as a "legal" observing site. Even if you are allowed to use a park after dusk, there is a very important concern when considering parks and other wooded urban areas as observing sites: your personal safety.

Security and the City Lights Astronomer

My astronomer friends who live in the country are always surprised that I'm not "afraid" to observe in the city. I find this a little funny, as the only times I've felt overly nervous while observing have been when I've been alone at a location far out in the country. I know what to expect in the city, and, whether at home or at one of my other in-town locations, I've never felt anything but safe. There is no doubt that safety *is* an issue for urban astronomers, though; particularly those who choose to observe from public-accessible sites where the very things that make the location attractive—fewer streetlights and the presence of wooded areas to block stray illumination—may cause genuine safety concerns. If you choose to use a public area, the first step to safety is in *knowing your observing site*. Is there a genuine crime problem? Are there gangs or homeless persons in the park after dark? If, after checking the park or other location personally (after dark) and perhaps talking to area residents, you turn up any "yes" answers, I would discourage you from attempting to use said site—alone, anyway.

Even if you judge an urban park or other public site "safe," you should still keep security in mind while planning and conducting observing sessions. There are some things you can do to help ensure your safety when observing away from home in the city (or, really, anywhere else). The first is to use the buddy system. If you have an active, enthusiastic friend, taking her or him along with you on your observing expeditions can go a long way toward ensuring your safety. A couple of friends is much better. I think it is *always* wise to observe with a companion when away from home, no matter how supposedly secure your site. Criminals and crazies will almost always be less than anxious to take on a group, but may see a lone person as "prey." Also very important: always let someone know where you will be and when to expect you back.

"What can I take with me when observing to help keep me safe?" When my fellow American amateur astronomers ask me this question, it's usually a polite and roundabout way of asking whether I think they should carry firearms when they observe. In my younger days, I would sometimes take a handgun with me—when observing alone far out in the country, never in the city—but I never, ever, had recourse to use my "piece." *Not even close.* In my opinion, a gun, a dark site, and a nervous astronomer, especially one not overly familiar with firearms and firearm safety, can be a recipe for disaster. Very easily. Other reservations aside, a gun is not a solution for a very good, practical reason: *if you are so nervous about your safety at an observing location that you feel the need to pack a firearm, you will most certainly not be able to do any fruitful observing. You'll be too nervous to concentrate, and will be jumping at every sound.* Forget guns. For most of the world's amateurs, especially those in the UK and Europe, a firearm isn't an option anyway. But there is an item you *can* take along to help ensure your safety, a cell phone. The cell phone, in my opinion, is a must for anyone observing alone anywhere, and is much more useful than a pistol. The gun won't be much help in the event of a dead car battery!

For the urban observer (or the suburban or country observer) the real way to safety is, again, the choice of a safe, comfortable site. If you feel secure, observing will be much more fun and you'll get a lot more accomplished. Of course, in the dark hours of the night it's easy to get spooked at *any* site. I recall one late evening in my familiar, safe, fenced backyard when I started hearing noises. Snapping twigs every once in a while. Eerie sounds of rustling leaves. Just as I was ready to run for the back-door, the psycho killer-UFO alien-werewolf turned out to be a friendly opossum, a common member of the urban fauna here, stopping by to say "hello" and see if I'd hand out some food.

The urban astronomer faces another security concern that's not related to the bad guys. It's the *good* guys. An amateur astronomer, either alone or with companions, is of immediate interest to passing police officers. This is understandable. You're out there alone in the shadows with a thing that, to the non-astronomy-literate law enforcement person, looks suspiciously like a *weapon* of some kind. Maybe a rocket launcher or a cannon. This would have seemed ludicrous a few years ago, but now, especially in the suddenly very security-conscious U.S.A., it is a very real scenario (understandably). Not just in the States, either. From talking to my astronomer friends all over the world, I conclude that it's not at all unusual anywhere for Joe or Jane Amateur Astronomer to be quietly admiring the heavens when the entire universe is suddenly illuminated with flashing lights and a stern voice intones, "Don't move!"

The secret to surviving these encounters in one piece and with your sanity and freedom intact is to do *exactly* what the officer instructs you to do. Assuming you're not some place you are not allowed to be, the policeman will usually end up being apologetic and will happily accept a view through the telescope (maybe, secretly, for final assurance that it's not *really* an ICBM launch tube). What can you do to avoid these encounters? If you observe from your home, let the neighbors know what you're doing: you're looking at the stars, not their bedroom windows, and it's you out in the yard with that funny tube, not a terrorist nutcase. If you're in a public area, make sure it's a location where nighttime access is allowed.

Let me emphasize this again, if confronted by the police, keep your cool and follow their instructions *to the letter*. Honestly, they have the right and the reasons to be curious and concerned about anything unusual they encounter on the urban landscape. Don't be scared off from your legal observing site, though. If the police seem to be hinting that you need to "move along," politely remind the officers that you're lawfully enjoying the park (or other location), just like the couple necking on the bench down the way.

Evaluating a City Observing Site

Now that you have a safe and convenient urban site to use for your observing runs, what can you *expect* from it? How bad is "bad" when it comes to observing the deep sky? Sky glow is a given. No matter where you go in the city, the sky is going to be bright due to the presence of thousands of unshielded or poorly shielded lights. You can't do anything about that. Your main concern is the *other* part of the city light pollution equation, the part you *can* do something about, ambient light. Ambient light is the stray light from nearby fixtures that's shining directly into your eyes. In some ways it is even more harmful than sky glow, since you could see a lot more, even in your city's compromised sky, if your eyes could gain some measure of dark adaptation. With a brilliant security light shining straight into your face, your pupils will remain as constricted as they can be, and even a bright open cluster will be hard to see. If you must choose a site that's badly affected by ambient light, there are ways to block it from your view, as we'll see in Chapter 3, "Accessories for Urban Observers." It's best, however, to seek a site that's shielded in some way from direct light if at all possible. A building, a tree, or a simple light shield (also in Chapter 3) can improve your ambient light situation a lot.

You'll also want to know the *limiting magnitude* of your city and your site. "Limiting magnitude" simply means, "How dim are the stars I can see with my naked eye?" In dark country you may be able to "see" down to magnitude 6 or even 7, which will mean the sky is festooned with countless of stars. From a heavily light-polluted city, you'll probably be limited to magnitude 4 or 3 stars. It's rare for things to be much worse than that, as, at magnitude 2, even a bright star like Polaris is barely visible. Possible in the largest and most light-polluted cities, but not likely. If you can't see a second magnitude star from your site, the likely cause is *ambient* light keeping your pupils "stopped down." A location that will allow you to see magnitude 4 stars away from the bright horizon will be a very good site and will provide countless hours of star-gazing enjoyment. Even a magnitude 3 site is quite usable, especially on evenings when the sky is dry and clear or if you restrict your observations to areas approaching the zenith.

How do you determine your limiting magnitude? It's easy. Find a constellation that's well away from the horizon and note the dimmest stars you can see. Away from the horizon because light pollution is always at its worst near the horizon. The poor atmospheric seeing, dust, and thick air there mean you won't want to observe objects below about 30° in altitude, anyway. A traditional tool for determining limiting magnitude is the Little Dipper, Ursa Minor (Figure 1.1). It provides a good spread of star brightnesses from magnitude 2 on down to magnitude 5 in a relatively small area of the sky. For best results, wait until all parts of the dipper are well away from the horizon before you use it. Also try to wait for a night that's pretty average as far as transparency and humidity go (high humidity skies scatter light and make existing light-pollution worse) so you get a good idea what to expect most of the time. Once

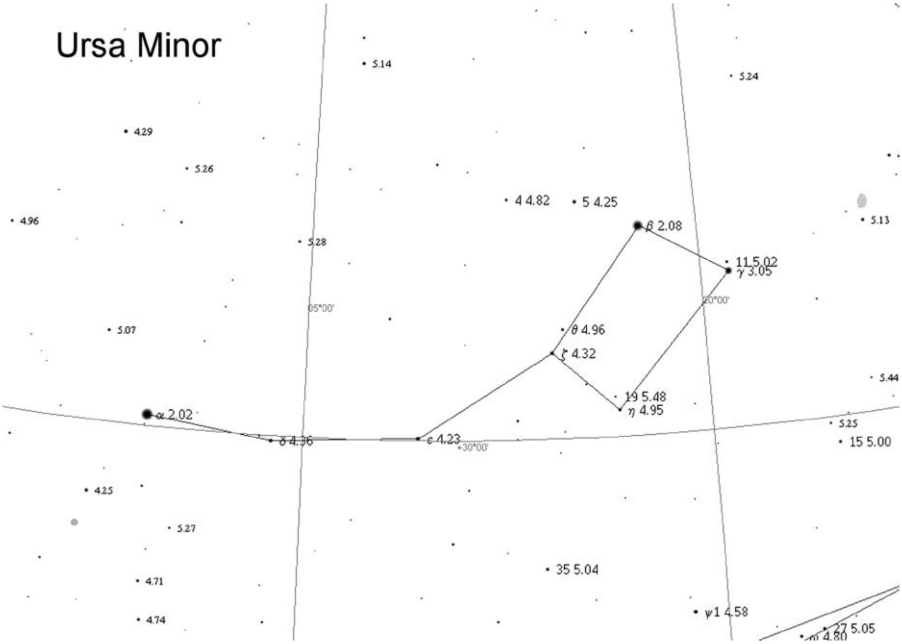


Figure 1.1. Use Ursa Minor to determine your limiting magnitude.

you know the condition of your sky, you'll be able to choose appropriate objects for an evening's observing program and will know, to some extent at least, how hard a "DSO" (deep sky object) will be to track down and observe.

Once you know *where* to observe, what do you observe *with*? Telescope choice is important for any amateur, but choosing the optimum instrument is critical to your enjoyment of the urban sky. The following chapter will help you select a telescope to serve as your urban starship.

CHAPTER TWO

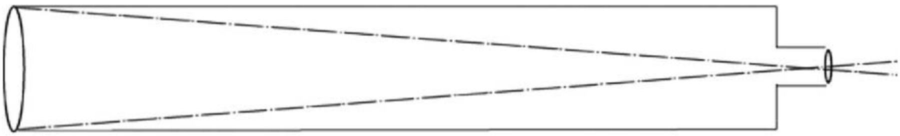
Telescopes for Urban Observers

What's the best telescope for the city-bound deep sky astronomer? If you already own an instrument, *that's it.* Almost any telescope, perhaps with a few simple modifications, can work well as your urban starship. Not all telescopes are created equal, however, and if you're thinking of expanding your telescope arsenal or buying your first instrument, you now have the chance to acquire one with your personal observing environment in mind.

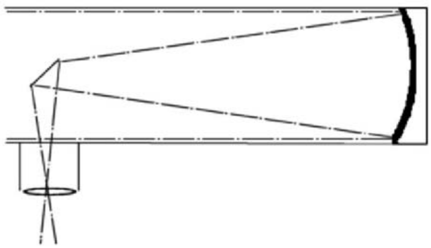
Telescope Types

Before you can select a telescope in an educated manner, you need to become acquainted with a few of its characteristics. There are three basic designs: the refractor, which uses a big lens (usually referred to as the "objective") to collect light; the reflector, which uses a large concave mirror (the "primary" mirror) for the same purpose; and the catadioptric telescope, which uses a combination of lenses and mirrors to grab starlight (Figure 2.1 shows the most common designs). Two simple specifications will tell you a lot about a telescope of any design.

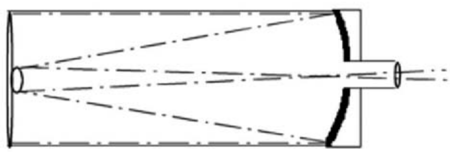
The first specification is *aperture*, the diameter (expressed in millimeters for small scopes and sometimes inches for larger ones). This indicates how much light the telescope can collect. *Light* is what you want, whether you observe from the city or the country. Any scope can be magnified to any extent. Plenty of light is what's needed, not the higher magnification. The department stores are filled with "600 power" 60-mm aperture scopes in alluring boxes festooned with Hubble Space Telescope images. Some of these scopes are actually fairly good optically, but, unfortunately, they are completely useless at high magnifications claimed for them. High power with a small



Lens Type (Refracting) Telescope



Mirror Type (Reflecting) Telescope



Lens - Mirror Type (Catadioptric) Telescope

Figure 2.1. Major telescope designs.

telescope makes everything dim to the point of invisibility. Images in the eyepiece must be bright enough for high power to be useful. A deadly dim globular cluster at 300× will show the observer *less* than what he or she could see at 100×. Light gathering power depends on the area of the lens or the mirror, so an objective lens or primary mirror with twice the diameter of a smaller one will collect four times as much light.

The second important specification is the *focal length* of the scope, the distance from the lens or mirror where the image comes to a focus. It is commonly expressed in millimeters, even if the mirror size is given in inches (don't ask me why). Longer focal length telescopes deliver higher magnification for a given eyepiece. A scope with a focal length of 750-mm, for example, will provide 30× with a 25-mm focal length eyepiece, whereas a telescope with a focal length of 1,200-mm will provide a magnification of 48× with the same 25-mm eyepiece (magnification can be calculated by dividing the focal length of eyepiece by the focal length of telescope).

Focal ratio is very similar to focal length. It is the mirror (or lens) aperture divided by the focal length of telescope. A telescope with a 150-mm mirror and a focal length of 1,200-mm has a focal ratio of $f/8$. Similarly, a 150-mm aperture telescope with a focal length of 750-mm yields, a focal ratio of $f/5$. Smaller focal ratios for a given size of objective mean shorter focal lengths, lower magnifications, and wider fields.

Larger focal ratios denote larger magnifications and narrower fields. These focal ratio numbers will soon become second nature to you when it comes to evaluating telescopes. If you see "*f*/4," you'll think "low magnification and wide field." A focal ratio of "*f*/10" will mean "high magnification, narrow field." With these few simple scope characteristics in mind, you're almost ready to start considering "which scope" in detail. Before looking at urban telescope candidates, however, I want to put to rest an old and silly myth.

The Urban Aperture Myth

You've heard it before, from local amateurs, on Internet astronomy discussion groups, and even from prominent astronomy authors who should know better: "If you live in the city or heavily light-polluted suburbs, don't buy a large aperture scope. A big mirror or lens will collect more light, but this will include more sky glow, more light pollution. The sky background in a big scope's field of view will be so bright that you'll see more with a smaller instrument. Get a 4-inch refractor, not an 8-inch Schmidt-Cassegrain or 12-inch Dobsonian reflector." Sounds reasonable and sensible. Big scopes gather more light, both from distant deep sky objects (DSOs) and from the background sky glow in your light-polluted skies. Choose a nice, small scope instead.

The problem with this theory is that it is a nonsense. Even though a big scope does collect more light from the bright sky background, *its deep sky images always look brighter and more detailed.* In order to prove or disprove this urban-aperture-limitation theory, I set up a small aperture 4.25-inch Newtonian reflector next to my largest scope, the 12.5-inch Dobsonian. I then pointed both at M13, the marvelous globular star cluster in Hercules. Assuming the urban-aperture theory was correct, the views in both instruments should have been similar. The 12.5-inch Dobsonian would yield an image so washed out by bright sky background glow that no more details would be visible in the cluster than in the 4.25-inch Newtonian reflector.

When the smaller scope was pointing at M13, I inserted an eyepiece that yielded 48× and took a look. It looked nice! The great cluster was easily visible, bright, and seemed as if it might *want* to resolve into myriad stars with higher magnification, but I wasn't able to see any individual stars at 48×, not even around the cluster's edges. What would I see in the 12.5-inch scope? I moved the eyepiece to the larger scope, where it gave the roughly comparable magnification of 65×. WOW! M13 didn't just look *nice*—despite my less than dark skies, it was a *marvel.* Many, many tiny cluster stars were visible, and, with the globular riding high in the sky, I seemed to resolve it across its very core with averted vision. It wasn't just a round glow; it was a big ball of stars. What a difference!

Maybe the comparison wasn't exactly fair? The 12.5-inch scope's slightly higher magnification could have given it an overwhelming advantage. I searched around in my eyepiece box and came up with a longer focal length ocular that gave me a magnification of 45× in the 12.5-inch instrument. Nope! The view in the 12.5-inch scope was still better, much better, than the attractive but unresolved view in the 4.25-inch. Frankly, in the 4.25-inch scope, M13 looked like a fairly unimpressive smudge. A bright smudge, but a smudge nevertheless. Also, to my eye, the field background really didn't look much brighter in the 12.5-inch scope than it did in the 4.25-inch. The background was bright in both instruments, but, to me, not noticeably moreso in the larger instrument.

Maybe the aperture gap was just too great. Perhaps an 8-inch would be a more worthy opponent for the big 12.5-inch than the little 4.25-inch in the city? I set up an 8-inch $f/7$ Newtonian reflector that I had on hand and took a look at Hercules. The cluster was better than it was in the 4.25-inch scope, but the view was not nearly as good as in the big 12.5-inch Dobsonian. M13's appearance in the 8-inch was considerably better than it was in the 4.25-inch scope, though—some stars were easily visible. The conclusion was unavoidable. In the city, as in the country, *aperture wins*. The larger your lens or mirror, the better the view.

When people ask me about the urban-aperture myth these days, I reply, "If you observe in light-polluted areas, always choose the largest aperture telescope you can afford and transport. In the city, aperture always wins." In fact, I've come to believe that aperture is more important in the city than it is in the country or suburbs. From a dark site, a surprisingly small scope will show a lot of deep sky objects in detail. At a pitch-black desert location, my little 4.25-inch reflector would undoubtedly have done better on M13 than it did in the city. No, it still wouldn't have kept up with the 12.5-inch scope, but the cluster would've looked better; some stars would have been resolvable.

If the sky is bright, you need all the aperture horsepower you can muster. Don't let anybody convince you otherwise with tales about the "bright sky background." If the field in your larger aperture telescope looks annoyingly bright, increase the magnification—that will darken it. But at *any* magnification, deep sky objects will show more detail with large aperture than with a small scope.

How Much Aperture?

The foregoing would seem to eliminate small telescopes for city use. That's not strictly true. Large aperture is always best, all things being equal, but all things are *not* usually equal. My big Dobsonian-mounted Newtonian works for me, living in a single-family home with a backyard, but if you live on the 12th story of an apartment building, you'll find hauling a big scope up and down a bit troublesome in an elevator and completely impossible if you have to negotiate stairs at any point—to access your building's roof, for example. If you're in a situation where you have to transport the scope to observe, pick a telescope with only as much aperture as you can *handle*. Try not to go too small, though.

If you can gain a sizable performance increase by going to a larger telescope that's only slightly more difficult to move, by all means do so. For example, given the choice between a 4-inch medium focal length refractor and a 6-inch Newtonian reflector, I'd always choose the 6-inch Newtonian reflector. The 6-inch reflector is slightly more difficult to move around than the 4-inch refractor, but only slightly, and it's worth the extra trouble for those additional 2 inches of aperture. Since it's an area that counts, the jump from 4 inches to 6 inches makes a big difference in what you can see. You'll hear a lot about the superiority of refractors with respect to contrast and image sharpness. Some of what you hear is true, but for the urban deep sky observer, again, the prime requirement is *light*. A 6-inch reflector will deliver more precious light than the 4-inch refractor.

How Much Focal Length?

Given the choice between a short focal length, small focal ratio scope, say, a 6-inch $f/4$ (focal length 600-mm) and a 6-inch $f/8$ (focal length 1,200-mm) for use in the city, I'd pick the $f/8$. Why? Larger telescopes are not handicapped by bright city skies any more than smaller telescopes, but all telescopes are naturally troubled by the relatively bright background of a low-power field delivered by scopes in light-polluted areas. In the country, nothing is nicer than touring the heavens with a low-magnification eyepiece. The sky background is velvety black and objects stand out in stark relief. In the city, the sky in your eyepiece is light gray rather than black. There's less contrast between the sky background and deep sky objects, and some dimmer DSOs may disappear altogether. Luckily, we can combat this bright field effect. Higher *magnification* increases the *contrast* between an object and the sky background—which is not to mention that you can duplicate country conditions by using high power, but it does help.

Why choose a larger focal ratio and longer focal length telescope for the urban use? A larger focal ratio scope produces *higher magnifications* for any given eyepiece. It's easier to reach a usable magnification for the city with common eyepiece focal lengths with a larger focal ratio scope. You don't have to resort to short focal length eyepieces—which are often uncomfortable to use—to achieve the higher powers you need, as you may have to do with a small focal ratio, wide field telescope.

Another benefit of large focal ratio instruments is their optical quality. Large focal ratio optics are always easier to make than smaller focal ratio optics, so, for a given price, a larger focal ratio scope may be considerably better optically than a smaller focal ratio scope.

A small focal ratio telescope may be desirable for the urban observer for easy portability, however. Smaller focal ratio, shorter focal length refractors and reflectors have shorter, lighter tubes than large focal ratio, long focal length instruments, making them easier to transport and store, which may be critically important for the apartment dweller.

Which One?

A quick browse through the amateur astronomy magazines will reveal a multitude of advertisements for a bewildering array of telescopes. The prospective 21st century telescope buyer is lucky that there is so much to choose from, but the endless color ads and manufacturers' enthusiastic claims and counterclaims make the task of picking a telescope confusing and maybe just a little bit frightening. The following section is designed to make this process less scary. In the next few pages, I'll look at the major telescope types with an eye toward their suitability for use in the city. I'll also consider some specific models. Since there are more commercial telescopes available today than

I could possibly provide educated hands-on reports for, the fact that a certain brand or model is not represented here does not necessarily mean that it is a bad scope or a bad scope for the city. It may just mean that I haven't gotten around to trying it. But the listed telescopes are my favorites and ones that I've had the chance to use in the city—often extensively.

The Refractor

Prior to about 20 years ago, the refractor, the time-honored "big lens" telescope, was dead when it came to amateur astronomy. Refractors, once much-loved by amateurs, had, with their big price tags, colorful images (as in chromatic aberration) and long, unwieldy tubes been left in the dust during the 1970s and 1980s by Schmidt Cassegrains and big Dobsonian (Newtonian) reflectors. But the refractor has staged a remarkable comeback, and it is now once again a popular and logical choice for any amateur and certainly for the city observer.

What brought the refractor back? Three things. First, the premium color-free apochromatic objective lens designs pioneered by Astro-Physics and TeleVue in the United States and Takahashi in Japan. Refractors suffer from chromatic aberration—a problem that's plagued these scopes since Galileo's day. An achromatic refractor, i.e., a telescope with a two-element objective made of crown and flint glass, the most popular design of refractor objective lens for the last couple of centuries, cannot bring all colors of light to focus at the same point. The practical effect of this is that bright objects like the Moon, Jupiter, Venus, and brighter stars are ringed with purple halos. This "excess" color is not only distracting—for some observers, very distracting, as some people seem more bothered by chromatic aberration than others—it tends to obscure detail and soften the image.

The apochromatic ("without color") refractor solves the chromatic aberration problem. Sophisticated lens designs and innovative materials—the use of fluorite "glass" is common—make the "color purple" a thing of the past. The color-free nature of these telescopes allows them to show the refractor's strengths to best advantage: good contrast due to the lack of a central obstruction (from a secondary mirror), a maintenance-free sealed tube, and little need to allow the telescope to adjust to outdoor temperatures. Couple this with the mechanical perfection the APO makers lavish on their *beautiful* creations, and you have very capable telescopes with heirloom quality. Naturally, this comes at a high price. Apochromatic telescopes are the most expensive telescopes per inch of aperture, and the prices really skyrocket once you get above the fairly modest aperture of 5 inches.

The second reason refractors returned was an emphasis on smaller focal ratios. In their earlier incarnations as amateur telescopes, most "featured" focal ratios as large as $f/16$. Few were seen "faster" (i.e., with smaller focal ratios) than $f/12$. This was done in an effort to reduce chromatic aberration, as at large focal ratios with their resulting long focal lengths, color is reduced for any achromatic objective. In theory this is a good idea, but at these very large focal ratios, once you got above a few inches of aperture, fields were very small and magnifications very high for any given eyepiece. Photography of deep space objects was difficult due to the very long exposures such "slow" optical systems required. In addition, the tubes were long and awkward (almost

6 feet long for a 4-inch telescope), and discouraged the user from moving the scope often, whether to dodge lights or to travel to dark sites. All in all, these telescopes were for an older version of amateur astronomy, one that focused on Moon, planets, and a few bright DSOs.

Today's refractors, and especially the apochromats, offer up delicious wide fields and fast focal ratios that make them attractive to deep sky fans. With focal ratios from $f/5$ to $f/6$ typically, a stunning view of the Pleiades or the whole sword of Orion is possible in the smaller apertures. This smaller focal ratio popularity has also affected the achromats, which now hover around $f/8$–$f/10$, with $f/5$ s also popular. It is almost unheard of to find any type of refractor with a larger focal ratio than $f/10$ these days. This works very well for the apochromats; they can deliver low powers and wide fields but, due to the superb quality of their optics and the lack of color problems, they still allow high magnification viewing. Achromats with shorter focal ratios are less successful. Even at $f/10$, color is quite noticeable, and, due to chromatic aberration, higher magnifications cause rapid breakdown of image sharpness.

The final key to the resurgence of the lens-scope? The influx into the West of very inexpensive but relatively well-made Chinese (Mainland and Taiwan) refracting telescopes. At this time, most of the Chinese refractors are traditional achromats, but they are relatively well made and perform well considering their low prices. These low prices have allowed many of us to enjoy an experience that, for those of us who entered astronomy in the 1960s or before, always seemed impossibly expensive: owning a "big" 6-inch refractor.

Are refractors a good choice for the urban astronomer? Yes and no. They are a very good choice if portability is a major concern. An $f/5$ or $f/6$ refractor in the 5-inch or smaller aperture range is easily manageable, even if the owner must reach her viewing site via multiple flights of stairs. The problem comes when it's time to increase magnification. Urban observers often use higher powers than country-based astronomers. As explained earlier, this darkens the field of view and allows DSOs to pop out of the normally gray sky background. If the $f/5$ or $f/6$ telescope in question is an apochromat, no problem. Just run the power up as much as you want. But be aware that you may have to use very short focal length eyepieces to reach this desired power.

If the refractor in question is a small focal ratio achromat, however, you may find it all but unusable in the city. A 4-inch $f/5$ Chinese achromat, for example, will often "top out" at around $100\times$. At higher magnifications, images become impossibly blurry due to a variety of optical imperfections, and that is a big problem in the city, as $100\times$ is often not nearly enough power.

Does that mean urban astronomers have to pay for an apochromat if they want a refractor? Maybe not. My tests have shown that at least some bargain Chinese achromats can be pushed to higher powers if you are content to stay away from the Moon, planets, and bright stars. Avoiding the bright, color-plagued objects helps these scopes keep it together magnification-wise a little longer. But even on dimmer DSOs there's no avoiding the fact that the short achromats deliver their sharpest images at low powers.

If there's one thing that argues against the refractor, achromat or apochromat, as an urban astronomy tool, though, it's aperture. 6 inches, 150-mm, of aperture is about where the city astronomer needs to *start*. That's big enough to start pulling some interesting objects out of the light pollution. 8 inches, 200-mm, of aperture is even better. Unfortunately, even a lightly built Chinese 6-inch refractor is B-I-G. It's not something you'll want to waltz from one side of the yard to the other to avoid porch lights, much less carry down four flights of stairs. Premium 6-inch refractors are even worse. They and their mounts are large and very expensive. An 8-inch apochromat is not only huge (as a portable scope), it's hugely *expensive* for most amateurs. In contrast, an 8-inch Newtonian reflector is relatively light, inexpensive, and especially on the deep sky, can deliver *most* of the image quality of an APO costing 10 or 20 times as much.

Refractors have a lot of charm, and I wouldn't fault you for choosing any of the scopes listed below, but for those of us condemned to do most of our observing under the glow of sodium streetlights, there are arguably better choices.

Synta

While most of the telescopes in our survey are sold under a single name, the Synta refractors are confusingly offered wearing many badges. These popular telescopes, both "short-tube refractors" and longer focal length scopes, all made by the same Taiwanese firm, are widely available in the United States and Europe under numerous brand names, with "Skywatcher" and "Konus" being plentiful in Europe and the U.K. and "Orion" and "Celestron" being the name plates on most U.S. models. They are all very much the same with typically the only difference from one brand to the next being the color of paint on the tube.

Synta's Short-Tube Refractors

Synta produces a full line of short focal length achromatic refractors, all with focal ratios of $f/5$. In addition to the original short tube, the Short Tube 80, an 80-mm $f/5$ refractor, which was the first Synta to become popular with U.S. amateurs, the company also offers a 102-mm $f/5$, a 120-mm $f/5$, and a (seldom seen in America) 150-mm $f/5$. How good are these scopes? Pretty good, considering their low prices. In some ways the best of the lot is still the 80-mm $f/5$ (Plate 2). Its smaller objective with its smaller amount of chromatic aberration and resulting ability to take higher magnifications than its bigger brothers makes it more versatile. It's a little handicapped for city use because of its small aperture and small focal ratio, though. The larger models display more excess color and are less able to handle higher magnifications, but, as mentioned earlier, staying on the deep sky enables them to do higher powers more gracefully than if you attempted the Moon and planets, subjects for which they are not well suited.

Synta's Medium Focal Length Refractors

Synta is famous for its short tubes, but its medium focal length telescopes are nearly as popular, with the 102-mm $f/10$ refractor a close second in popularity to the 80-mm $f/5$. All these refractors have focal ratios close to $f/10$ and all come equipped with workable German equatorial mounts, the medium-sized EQ3 for the 102-mm and the EQ4 for the larger models. In addition to the 102-mm, Synta offers a 120-mm and a 150-mm refractors.

All of Synta's larger focal ratio refractors with their resulting longer focal lengths are reasonable choices for urban use. One thing the prospective buyer should remember, however, is that the focal ratio of $f/10$ is still small when it comes to reducing color in achromats. Focal ratios would have to be half again as large for color to begin to disappear, especially with the 120-mm and 150-mm telescopes. These refractors can do a good job on the deep sky, however, with only the brightest stars showing much disturbing color.

Meade

Meade's Achromatic Refractors

The U.S. company, Meade Instruments Corporation, is most well known for its Schmidt Cassegrain telescopes (SCTs), but it also offers some refractors of interest to the urban astronomer. Once you get beyond the small, cheap department store scopes Meade imports and sells, you are left with three interesting achromats. The ETX 80 is a short focal length $f/5$ refractor on a computerized fork mount. Equipped with its Autostar controller, this little wonder will automatically find over a thousand objects. In another class altogether are the AR5 and AR6 refractors (127-mm and 152-mm apertures, respectively). These telescopes are part of the company's LXD-75 series, and are mounted on German equatorial mounts that, with the included Autostar computer, will automatically point them at tens of thousands of objects. Naturally, only a small subset of these will be visible from our light-polluted haunts.

The ETX 80 is a cute little scope. I own and use the very similar ETX 60 (now discontinued), and have had a lot of fun with it. Unfortunately, its short focal length means that, like the Synta short tubes, it's best suited for dark skies and wide-angle DSO viewing. In my experience, it can beat the Synta 80-mm $f/5$ in the city, since the go-to feature means that it's easier to locate objects in bright skies. Image quality is similar to the 80-mm in brightness, but the 80-mm $f/5$ s usually do better on the planets.

The AR5 and AR6 are interesting for a couple of reasons. First, their prices are surprisingly modest. They also possess apertures that move into the range suitable for deep sky viewing in the city. Most observers have given good reports on the optics that, while imported, seem slightly better on average than those in the comparable apertures Synta telescopes. The Chinese-made LXD-75 GEM mounts seem well-thought out if a little rough around the edges, and the computer features really work if the telescope is carefully aligned.

Meade's ED Refractors

Meade also offers a line of "almost" apochromats, the ED series. They are more expensive than the achromats, but much less pricey than true apochromats from premium class telescope makers. These telescopes, available in apertures from 4 to 7 inches, as tube assemblies only or on computerized mountings, have been reasonably popular with amateurs. With the exception of the 4-inch, they are a little heavy for the average urban observer, though, and, mechanically they have had a few problems.

The focusers on Meade's inexpensive AR scopes are considerably better, for example, than those on the more expensive ED models. Meade has done little advertising and promotion of these instruments in recent years, and, while they are still offered, I'm not sure how much longer they will be around. I expect them to be replaced by comparable aperture Chinese ED semi-apochromats "any day now."

TeleVue's Telescopes

TeleVue is justly famous among amateur astronomers for its premium wide-field eyepieces (see Chapter 3), but it also produces refractors second to none. The TV line starts out with the 70-mm Ranger and Pronto. These both telescopes use the same 70-mm *achromatic* objective (albeit with ED glass elements), but differ on mechanical features, with the Pronto, which features a 2-inch focuser, being heavier and more expensive. Both the Ranger and Pronto have been discontinued recently, but are still available from many dealers.

When it comes to genuine apochromatic refractors, TV offers the $f/6$ TV60 (60-mm), the $f/6.3$ TV76 (76-mm), the $f/7$ TV85 (85-mm), the $f/5.4$ NP101 (101-mm), and the $f/8.6$ TV102 (102-mm). All the APOs feature 2-inch focusers and premium fittings. TeleVue sells a line of alt-azimuth mounts in various sizes, but the telescopes are normally sold without mountings, allowing the user to choose one that best suits her/his needs.

The TeleVue APO refractors are excellent in every way. The images produced by those I've used have been as good or better than those of any apochromat I've tried. There are a couple of drawbacks to these fine scopes, however. First, there's the price. Like all top-of-the line refractors, they are expensive, with prices ranging from 700 US$ for the Ranger to 3,600 US$ for the NP101. Remember, these figures do not include the extra expense for mountings. The lowest priced TeleVues, the Ranger and Pronto are achromats. They may be somewhat better than the average Synta Short Tube when it comes to chromatic aberration, but will not be color free.

You do have to expect to pay for perfection, of course, and that's what the TVs deliver. But there's a second and more serious quibble. A 4-inch is a 4-inch is a 4-inch. No matter how finely crafted a telescope is, aperture is *still* the key, no matter what the design. A 4-inch is *usable* in the city, but more aperture is better. The 101 and 102 scopes are the *minimum* for serious urban work. If you can pay the fare, though, go for it. A TV101 or 102 on a comfortable alt-azimuth mount and equipped with a digital setting circle (DSC) computer (also available from TeleVue) is a portable setup that will last a lifetime and one that may surprise you with its performance, even under city lights.

Astro-Physics

If any name is associated with the rebirth of the refractor, it's "Roland Christen." Mr. Christen, the founder of the U.S. firm Astro-Physics Incorporated, "AP," has been turning out world-class refractors for over 20 years. His telescopes are considered by many amateur astronomers to be the best in the world. Currently offered are the $f/7$ Stowaway (92-mm), the $f/6$ Traveler (105-mm), the $f/6$ Starfire (130-mm), and the $f/7$ Starfire (155-mm). The Starfires are all literally *color free*, and the color error in the smaller scopes is so small as to be of technical interest only. In addition to the telescopes, Astro-Physics also sells their own line of computer-equipped go-to German equatorial mounts.

Can anything bad be said about Astro-Physics telescopes? Not really. For what they are, they are exquisite. Naturally, as with the TeleVues, this comes at a price. While very reasonable when compared to other premium brands, the APs don't come cheap—the 92-mm costs 2,880 US$ and the top-of-the-line 155-mm quipped with all the options commands as much as 8,800 US$. On suitable mounts, the 5- and 6-inch refractors, like all examples of their breed, are less than portable, and, in most cases, not something the apartment dweller should consider. Aperture is a problem, too. A 6-inch aperture is good, but not great when you're faced with bright skies. Finally, you can't just go out and buy an AP. To get one, you'll wait three years or *longer*. Despite their prices the scopes are very popular and are produced in very limited numbers. "AP" is currently in the process of switching from the above telescope models to some new designs, and that may possibly result in even longer waiting list for these super-premium telescopes.

Others

For the "price is no object" crowd there's Takahashi. These Japanese APOs are very close in image quality to the TVs and APs. The trade-off is that they are considerably more expensive. They are available immediately—no waiting list—however. An up and coming company in the U.S. is "TMB Optical." This concern, named after the initials of owner/designer Tom Back, is producing telescopes that are very well regarded by amateurs, are comparable in quality to the rest of the premium pack, and, at this time, are available a lot sooner than the APs. For the achromatic refractor enthusiast, D&G Optical (U.S.) makes achromats in a variety of focal lengths (including long ones) that are in the premium class compared to the humble Syntas.

Newtonian Reflectors

If you ask an advanced amateur astronomer which telescope is "best" as a first, serious purchase, 9 out of 10 times the reply will be "Newtonian reflector." These simple, inexpensive telescopes do have a lot to offer observers—in or out of the city. Their main strength is certainly their dollar/aperture ratio. When it comes to aperture for your telescope money, nothing beats a Newtonian. There are some expensive, premium examples, but it is quite possible to get a working 16-inch Newtonian for just over 1,000 U.S.$. This design is also quite versatile; a properly made Newtonian with a well-made primary mirror is capable of handling a wide range of magnifications and delivering outstanding images of planets and DSOs.

Potential problems with Newtonians for the urban astronomer? The lower priced models are Dobsonians, "dobs" (named after their popularizer, John Dobson), which are Newtonians mounted on simple alt-azimuth up–down/left–right mounts usually made of wood or particle board. Their tubes are often made of cardboard Sonotube™ concrete form tubing. These "cheap" construction materials are not as bad as they sound—wood and Sonotube™ provide a sturdy and thermally stable body for a Newtonian. Unfortunately, the simple Dobsonian mounting is not easily equipped with motorized go-to for automatic object location, which is a desirable—highly desirable—feature for the urban astronomer. Dobs *can* be furnished with Digital Setting Circle computers that will help guide you to objects, but in my experience these DSC systems are not nearly as accurate as go-to. Tracking is also not easily implemented. With a Dobsonian, you'll be nudging the scope continually to keep objects in view, and this can be annoying at the higher powers used in the city.

Thanks to the Taiwanese and Mainland Chinese telescope factories, nicely priced motorized equatorially mounted Newtonians that can automatically track the stars are now available in addition to alt-azimuth mounted Dobsonians. The equatorial telescopes are generally found in smaller focal ratios than the dobs, something that, as we've said, the urban observer may not find as useful as higher focal ratios. But the high quality of the current Chinese mirrors means that the equatorial scopes can often be pushed to as high a magnification as needed while maintaining sharp, clear images. The larger apertures of these scopes, 8 and 10 inches, means that even at $f/5$ it's fairly easy to produce high powers without intolerably short eyepiece focal lengths.

All in all, Newtonians are a laudable choice for the city. They fulfill our prime requirement—they deliver lots of light—at bargain prices. They are also easy to transport in sizes up to about 12 inches, don't require long to adjust to outdoor temperatures—any telescope mirror must cool down or warm up to ambient outside temperature before it can deliver its best images—and can provide images easily equal to those of any other design of telescope.

One thing to be aware of when considering a Newtonian as a city scope is what I call "The Only Enemy of Good Enough is More Better" syndrome. With prices for Dobsonian Newtonians so reasonable, novices may be tempted to buy bigger than is easily portable in an urban environment. Consider 12 inches the *absolute* upper limit and 10 inches the *practical* aperture limit for most city-based observers.

Meade Dobsonians

Meade Instruments has been selling a line of Sonotube Dobsonians (Plate 3) since the early 1990s, and these simple telescopes have garnered much praise for their optics. Until recently, these "StarFinder" Dobsonians were available in 6-, 8-, 10-, 12-, and 16-inch apertures. Meade has now changed focus, going to Schmidt Newtonians (see the "Catadioptric" section) for their smaller non-SCT design scopes, and only the 12- and 16-inch StarFinders are now available new. The 6-, 8-, and 10-inch sizes are plentiful used, though.

While all these telescopes have surprisingly excellent optics, you'll often hear them described as "kits." That's because at the very low prices Meade asks for these scopes (845 U.S.$ for the 12.5-inch $f/4.8$, and 1,245 U.S.$ for the 16-inch $f/4.5$) they've had to scrimp on everything other than the mirrors. The focusers (plastic) and finders