Purchasing Amateur Telescopes FAQ

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This FAQ is under construction . There may be some sections that are not totaly done yet.

Contents (Questions in this FAQ):

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1. What is the single most important thing I should know before buying a telescope?

This is the single most important thing you should get out of this FAQ: DO NOT BUY YOUR TELESCOPE FROM A DEPARTMENT STORE.Ignore everything any literature tells you about magnification and such. Buy from a telescope store, where you will get a telescope that makes smaller claims, but will give you FAR better performance.

The reason is that as far as telescopes go, how much you can magnify is a function of the amount of light the telescope receives, which is almost entirely determined by the telescope‘s aperture (the size of the lens or mirror that points at the sky). As far as magnification goes, you can expect 50x per inch of aperture on a normal night.

Department stores always show little 2 1/4 inch refractors from 125+ dollars and say that the refractor can get up to a whopping 600x or so. Strictly speaking, this is true. However,applying the 50x rule, it is easy to see that 125x would be pushing the optics, and that is assuming that they were high quality ones. With the quality of the parts they usually give you are lucky to get 100x with reasonable resolution.

2. Recommendations for Beginning Amateur Astronomers

Occasionally, amateur astronomers ask for recommendations about telescope buying, learning the sky, and so on. Here are some thoughts.

(Let me state credentials. I am primarily a visual observer: Over 40 years I have logged about 6000 observations of nearly 3000 objects, and used perhaps thirty telescopes and binoculars enough to know them well. I have made roughly ten optical surfaces to 16-inch diameter (a sphere—my biggest paraboloid was 8 inches). My forte is deep-sky work; observations I am proud to include the Sculptor Dwarf Galaxy (10x70 binocular), Maffei I and Leo II (Celestron 14), and S147 (6-inch Maksutov). My interests led to a physics PhD, studying the interstellar medium from a spacecraft: By training I am an astrophysicist, but I maintain amateur status in visual wavelengths—my thesis work was in extreme ultraviolet.)

What to do First.

First, some meta-advice. Written words do not substitute for experience. Join an astronomy club, go to observing sessions, and try other peoples‘ telescopes. You will learn a lot, and will find people who like to discuss equipment and observing.

To find clubs, ask at science stores, museums, planetariums, and the like. Physics and astronomy departments of colleges may know, though clubs aren‘t strictly their line. Two popular astronomy magazines, *Astronomy* and _Sky_&_Telescope_, publish annual directories of clubs, stores, observatories, and such. Look for them on newsstands, or go to a library and read back issues, or try their web pages.

Been to a club already? Honest? Okay, you can keep reading...

Some Basic Questions.

In buying a telescope, you face bewildering, expensive choices. To help deal with the confusion, here are some questions to ask yourself.

- **How much effort are you willing to put into learning the sky?** If you know the constellations, and have practiced finding things by „star-hopping“—using charts instead of dial-in or punch-in coordinates—you will be able to use a telescope cheaper, smaller, lighter, and easier to set up than one using precise alignment or computer control to locate objects.
- **How much effort are you willing to spend on your observing skills?** Seeing fine detail in celestial objects, or just seeing faint ones at all, requires practice and special knowledge. Yet the rewards are enormous: An experienced observer may see things with a small telescope that a beginner will miss with one five times larger, even with objects and sky conditions that favor both telescopes equally.

- **How far will you have to lug your telescope to get it from where you keep it to where you use it, by what means, and how much effort will you put up with to do so?** Differences in size and optical design create vast differences in telescope portability, and any telescope that you take out and use will be far better than one that sits in the closet because it is too heavy or too cumbersome.

- **Some people are into technology for its own sake, without regard to whether it is useful or cost effective. Are you willing to pay extra for sophisticated features, even if you don‘t need them?** If so, fine— lots of us like neat equipment. But if not, take care technology enthusiasts don‘t sell you things you don‘t need.

- **Do you want to take photographs or CCD images of celestial objects?** „Astrophotography“ is an expensive word. I am not into this side of the hobby, but friends who are typically take several telescopes and several years before they are satisfied, and spend lots more money than visual observers do.

Some Realities.

With these thoughts in mind, I can make some general comments.

(A) The most important thing in determining the optical performance of a telescope is the diameter of the beam of light that goes into it— its „clear aperture“. Obviously, the more light, the fainter the things you can see, but less obviously, image detail is limited by clear aperture, via physical optics. Bigger telescopes produce sharper images, just because they are bigger.

There are important qualifiers.

> First, bad craftsmanship can make any telescope perform poorly. Cheesy optics won‘t work. Fortunately, it is not too hard to make optics of the sizes and types common in amateur telescopes: most manufacturers routinely turn out units that are okay. Bad ones turn up, but major manufacturers will often fix or replace a real lemon, if you have wit to recognize that you have one, and will to complain. (Most of us have neither; that‘s how some manufacturers make money!)
>
> Second, different optical designs perform differently. Schmidt- Cassegrains, Newtonian reflectors, and refractors all have good and bad points. People who love telescopes, or sell them, will be eager to debate the matter. However, variations are relatively minor. It is usually adequate to assume all telescopes of given clear aperture and given quality of optical craftsmanship have the same optical performance: Real differences will correspond to changes in aperture of usually no more than 10 to 20 percent. Shabby optical work will increase that percentage enormously.
>
> Third, atmospheric turbulence („seeing“) limits the ability of a telescope to show detail, and sky brightness limits its ability to show faint objects. Poor seeing usually hits large telescopes harder than small ones. When seeing is poor, there may be no reason to take out and set up a big telescope. If you always observe from such conditions, you may have no reason to buy a big telescope. Yet, even in bright sky, a large-aperture telescope will show fainter stuff than a small one. And many of us have found dark-sky stable-seeing sites within a reasonable drive of home—from sites near San Francisco Bay, sometimes I have to stare through the eyepiece of my Celestron 14 for several minutes before I can tell that there is any air between me and what I am looking at.

Notwithstanding these caveats, APERTURE WINS, and wins big. If you buy the finest 90 mm fluorite refractor in the world, do not be chagrined if a junior high school student shows up with a home-made 6-inch Newtonian that blows it clean out of the water: The 6-inch I made at 13 puts my world-class 90 mm fluorite to shame. There is no contest, and it‘s not because I was a master optician at 13, it is because six inches is bigger than 90 mm, hence intrinsically better.

(B) Hundreds of deep-sky objects are big and bright enough to show well through apertures of two inches or so, at low magnifications.

Thus, medium sized binoculars -- 7x50 or 10x50, say („7x50“ means „7 power, 50-mm aperture“) make inexpensive, highly portable, easily operated beginner instruments. Perhaps you have one already. To use them well, you must be willing to learn the sky enough to find things with a hand-held instrument. And don‘t get one that gets too heavy to hold steady before you are done observing.

Speaking broadly:

(C.1) The most optical performance per unit of clear aperture comes from modern, high-quality refractors— but they are outrageously expensive compared to other designs of the same aperture. Also,in sizes much above four-inch aperture, the tubes are generally long enough to make the whole instrument cumbersome and heavy.

(C.2) The most optical performance per unit of portability comes from Schmidt-Cassegrain and Maksutov designs—but they are still pretty expensive. There‘s a qualifier here: What makes them portable are short, stubby tubes, but for small apertures—say, four inches or less—portability of all types is dominated by clumsiness of the tripod, so the portability advantage of Schmidt- Cassegrains and Maksutovs diminishes.

(C.3) The most optical performance per unit of cost comes from Newtonians—particularly those with Dobson mountings.Compared to other telescopes of the same aperture, they are clumsier than Schmidt-Cassegrains and Maksutovs, but not nearly as clumsy as refractors.

Let me regroup that information into three questions telescope buyers often ask:

(C.1‘) What gives most optical performance for a given aperture?
Usually, a high-quality refractor.

(C.2‘) What gives most optical performance for a given car to carry it?
Usually, a Schmidt-Cassegrain.

(C.3‘) What gives most optical performance for a given budget?
Usually, a big Dobson.

(D) Though costly and cumbersome, small refractors are durable and difficult to get out of whack. Good ones make respectable beginner instruments, particularly for beginners with extra thumbs. And a good small refractor provides a wonderful way for an experienced observer to embarrass folks with humungeous Newtonians who lack observing skills to exploit them. But BEWARE of mass-marketed junk refractors, advertised as high-power and sold in department stores.

(E) Altazimuth mountings tend to be cheaper, lighter, less clumsy, and more quickly set up than equatorial ones, but to use one you must be willing to learn the sky well enough to find things without dialing in celestial coordinates. (Computer-controlled altazimuth mounts allow use of celestial coordinates to find things, or perhaps will look up the coordinates for you, in an internal data base, but they are not cheap.)

(F) There‘s another way to look at this material. There are variety of ecological niches for telescopes, corresponding to different uses and requirements. I know of seven:

(F.1) Big Iron: This is the giant Dobson-mounted Newtonian, or humungeous Schmidt-Cassegrain, that fills your garage. Totransport it requires a small trailer, pickup truck, or panel van, and setting it up calls for the concerted efforts of three used fullbacks and a circus elephant. The ladder to climb to the eyepiece is so tall you need supplemental oxygen to deter altitude sickness. This telescope is your galaxy-gazer and cluster-buster supreme, and if it is well made, then when the seeing is good it will show detail that those condescending high-tech dweebs with their confounded itty-bitty seven-inch apochromatic refractors can only dream about. My „Big Iron“ is a Celestron 14, with a little tiny single-axle cargo trailer to haul it.

(F.2) Largest Conveniently Portable Telescope: This is the most telescope that will fit easily in your regular vehicle without hiring a bulldozer to clean it out. What it is, depends on what your vehicle is—with a ten-speed, or a subway train, you have a problem. An eight- to eleven-inch Schmidt-Cassegrain is the right size for many people; that is one reason these telescopes are popular. I have had several Largest Conveniently Portable Telescopes, over the last few cars. Once I built an eight-inch Dobson whose key design parameter was that the tube just barely fit crosswise across my back seat. I used it a lot till I bought a smaller car. For a while, my Largest Conveniently Portable Telescope was a Vixen 90 mm f/9 fluorite refractor on an altazimuth fork or a Great Polaris German equatorial (I have hardware to fit both), but at present I use a six-inch f/10 Intes Maksutov on the Great Polaris. A somewhat faster Dobson than my 8-inch f/5 would work equally well, and would have more performance for most purposes.

(F.3) Public Star Party ‚Scope: You‘ll want something pretty portable, with the added provisos that it‘s nice to have a sidereal drive so you won‘t have to keep re-pointing it between viewers, and that it shouldn‘t be so expensive you worry about kids and idiots. Your SCT will do nice it. I put the Intes or the Vixen fluorite on the Great Polaris, but I set the tripod legs to maximum length, so the expensive optics are out of reach. So far, no one has slam-dunked a rock.

(F.4) Quick Look Scope: The idea here is to leave something all set up in your entrance hall, or hidden under a stack of old _Sky_&_Telescopes_ in the back of your car, so you will have a telescope on two minutes notice if a truly close comet comes whizzing by, or if you are too lazy to assemble one of your real telescopes. Such an instrument can also double for nature watching or spying on the neighbors, which may be the same thing just don‘t tell your fellow amateur astronomers, or you will lose observer points. Many people have a spotting ‚scope on a light tripod, or perhaps a 90 mm Maksutov on one a bit heavier. Lately, my Quick Look ‚Scope has been a 102 mm f/9.8 Vixen refractor with a conventional achromat, on a Vixen bent-fork altazimuth mount that has clutches and slow motions on both axes. I have a couple of smaller refractors that I sometimes use similarly, but since I have room to leave the 102 mm set up in my living room, I benefit from the extra aperture.

(F.5) Binocular: A good binocular is very useful, and can do much of the work of a ‚Quick Look Scope. I have too many; ones I use for astronomy include the 7x35 Tasco ($29.95 at Sears) that I keep in my car for bird-watching (oops, lost observer points), an old Swift Commodore Mark II 7x50 (long out of production), which was one of the first binoculars I saw with BAK-4 prisms, and an Orion 10x50 and 10x70 with BAK-4 prisms and fully multicoated everything, up to but not including the case. At star parties I tend to wander around with one dangling from my neck. I tried two, but lacked sufficient eyes.

(F.6) High-Tech Conversation-Stopper: This is how you put to shame those grass-chewing hillbilly clodstompers who have giant cardboard Dobsons with tubes so big that they echo. Odds are the seeing will never get good enough for them to demonstrate that a half-meter shaving mirror will blow eighteen centimeters of optical perfection clean out of the water, and if they start talking about faint galaxies you can always change the subject to diffraction rings and modulation transfer functions, and ask them to compare internal baffles and background sky brightness. Besides, your telescope has more knobs than all theirs put together, and it cost more than all theirs put together, too. The default choice for the High-Tech Conversation-Stopper these days is typically an apochromatic refractor, or some close approximation („apochromat“ is a precise technical term; not all superb refractors are apochromats, and vice-versa), which if well made and well baffled will deliver outstanding performance for its size. The apertures available suffice for many amateurs who have either recovered from aperture fever or have not yet succumbed, or who have exhausted their supply of fullbacks and circus elephants to set up the Big Iron. Few other kinds of telescopes qualify—you‘re not allowed to have a Schiefspiegler unless you can remember how to spell it, and nobody wants a Yolo because people expect you to walk the doggie. Some folks like Questars, but not me. My present High-Tech Conversation-Stopper is the 90 mm Vixen fluorite refractor I mentioned earlier. It is not big enough to be as impressive as I might want, and is rather short on knobs, but I can talk fast enough to make up the difference.

What about accessories?

I have already said most of what you need to know about accessories, which is that (A) aperture wins. If you are planning a telescope budget, and eyepieces, finders, and such account for the lion‘s share of your funds, sit back and think carefully about what you are about to do it might be better to get a bigger telescope instead of fancy accessories. A 10-inch telescope with a hand magnifier as an eyepiece will give a better view of most objects than an 8-inch telescope with the finest eyepieces in the world. Why? Because (A) aperture wins.
Yet if you are up against limits of telescope portability, or have lots of money, or like technology, go ahead and buy fancy accessories. I won‘t tell, provided you remember that (A) aperture wins.

In any case, I will mention some plain-vanilla accessories that you might want to have, and maybe a few chocolate ones, too:

(a) Eyepieces. A small number of good ones is better than a large number of bad ones. You will need a low-power, wide-field eyepiece, both for finding things and for low-power views of big, diffuse objects.

It might give a magnification equal to five or six times the telescope clear aperture, in inches. On my f/11 Celestron 14, the low-power eyepiece has a 55 mm focal length, and is mounted in a two-inch barrel, so that the front lens—which sets the field diameter—can be as large as possible. (In little f/10 or f/11 telescopes, internal baffles may mean that no light gets to the edges of a two-inch wide eyepiece; if so, don‘t bother with the extra cost of one.) On my f/5 8-inch Dobson, I use a 20 mm eyepiece, which doesn‘t need a two-inch barrel.
The next power you will likely reach for is medium to medium high, for a good look at detail in the object in view. Such an eyepiece might give a magnification of 20 to 30 times the telescope clear aperture, in inches. On my C-14 I use a 12.4 mm eyepiece, and on my 8-inch Dobson, a 4 mm. The objects you look at with high power probably won‘t be very wide (though they might be), so for economy, you might not want a super-wide-field type.

Your next choices will depend on what you like to look at. If you are not sure, hold off buying more eyepieces till you find out.

„Fast“ f-numbers, typical in Dobson-mounted Newtonians, require fancy, expensive eyepieces to give good views, because the steeply converging light cones of these instruments are difficult for an eyepiece to cope with, particularly away from the center of the field.

Slower instruments can use simpler eyepiece designs. It is a „Catch-22“ of amateur astronomy, that cheap telescopes (fast Dobsons) need expensive eyepieces, but expensive telescopes (most refractors and Schmidt-Cassegrains, with slow f numbers) can use cheap eyepieces.

„Zoom“ eyepieces, which change focal length at the twist of a knurled ring, tend not to be very good. Barlow lenses, also called telextenders, multiply the focal length of the telescope with which they are used: It used to be that they generally worked well only with telescopes with large f-numbers, where they were not needed—another „Catch-22“. Yet I have heard that there are now Barlow lenses that work with fast telescopes, where they are indeed needed, but I urge a try-before-you-buy approach to selecting one.

For over fifteen years I used an eyepiece set bought in roughly 1980. It featured no fancy designs, just a 55 mm Plossl, 32, 20, and 12.4 mm Erfles, and 7 and 4 mm Orthoscopics. The 55 and 32 mm eyepieces were in 2-inch barrels, the others in 1.25 inch barrels. All were very good quality—the 55 and 32 mm were from University Optics, and the others were Meade Research-Grade. All worked reasonably well even at f/5, and the 68-degree apparent field of the Erfles was enough that I was untempted to buy wider-field types. Besides, a big Erfle is already so heavy that I must rebalance the telescope to use one. I did use the 4 mm eyepiece on the C-14 now and then, but occasions where I want that much power are rare.

In mid 1996 I bought more eyepieces, mostly out of curiosity. I found that decent Plossls are comparable to decent Orthoscopics. I bought several Vixen „Lanthanum“ eyepieces, which have built-in matched Barlow lenses to give 20 mm eye relief, even at such short focal lengths as 2.5 mm. I don‘t need glasses to observe, but even so, long eye relief makes viewing more relaxed—I‘m not worrying about bumping the eyepiece. It also facilitates public viewing—I focus with my glasses on, and tell everyone to leave theirs on and not refocus.

Note what high-tech eyepieces can and cannot do. The best give wider fields of view, with fewer eyepiece aberrations near the edges, than older types. The improvement is most noticeable at fast f numbers. If that‘s important to you, you might want some. But eyepieces are not aperture stretchers. They can neither increase image detail beyond the theoretical limit for the aperture, nor increase the number of photons that make it to the focal plane. If you think otherwise, you are making the same mistake as the clueless beginner who buys a drug-store refractor because it says „Magnifies 400 Times!!“ on the box. The best an eyepiece can do is not make things worse. A simple eyepiece, with good coatings and well-polished lenses, will show all the on-axis detail a telescope has, and absorb almost no light. That‘s what counts most for astronomical work.

In 1980, I bought 6, 12 and 25 mm Ramsden eyepieces—an old, simple, design—for about ten dollars each. I use them at star parties without telling what they are. They have only four surfaces, so simple coatings give good throughput, and there are few chances for bad polish to scatter light and ruin contrast. The field of view is narrow, but on axis, at slow f numbers—f/10 or longer—they give up nothing to new designs; images are superb.

(b) Finders. What kind of finder you get depends on how you use it. If you plan on looking mostly at fine details in bright objects, then you might buy a big finder, in the hope that most of what you look at in the main telescope will be visible in it, too. But that won‘t work if you push your telescope to its faint-object limits—you would need a finder as big as the main telescope. You might then consider a finder that will show stars exactly as faint as on your charts. It helps a lot in identifying what you are looking at through the finder, if every star you see is charted, and vice-versa. Once the right pattern of stars is in the finder, you can put the crosshair where the object lies, even if it is too faint to see.

In dark sky, the 10x40 finder on my C-14 shows stars to about magnitude 9.5, which matches my big charts. The 7x35 on my 6-inch Maksutov does almost as well. In suburbia, the 5x24 finder on my 8-inch Dobson goes to about magnitude 6.5 (which would be the naked-eye limit in darker conditions), thus matches many naked-eye star atlases.

Unit-power finders, like the Telrad, let you to stare at the sky with both eyes open and see a dot, circle or crosshair of light where your telescope is pointing. A peep sight, made by taping bits of cardboard to your telescope tube, may work as well, and will be much cheaper, and any magnifying „straight-through“ finder (in which you look in the direction the finder is pointing) can be used with both eyes open let your brain fuse the images, so you can use the finder‘s crosshair with the other eye. I tried a unit-power finder (Orion‘s) on my 90 mm refractor, but found it always inferior to the original 6x30 finder.

My opinion about unit-power finders is in the minority. Many prefer them to those which magnify. Some folks use the Telrad‘s circles of known diameter to measure angular distances when finding things.

© **Charts.** Preferences vary greatly. What I find useful, in order from simple to complicated, is more or less the following:

(c.1) A simple planisphere, preferably *a plastic one* that won‘t sog out with dew and that may survive being sat upon. It‘s a fast way to find out whether a particular object is up before I go observing, or to determine how long I have to wait before it is well-placed.

(c.2) A „pocket atlas“. I am particularly fond of *Ridpath and Tirion‘s The Night Sky*, from Running Press in Philadelphia, PA. It is about three by five inches and half an inch thick, and it is out of print. Write Running Press and complain.

(c.3) A „table atlas“, bound as a book that will lie reasonably flat, showing stars to the naked-eye limit and lots of deep-sky objects to boot. I happen to use an old *Norton‘s Star Atlas*; there are lots of others.

(c.4) A „deep atlas“, such as *Uranometria 2000* or the *AAVSO atlas*, with a stellar magnitude limit of 9 or 9.5 and a vast number of objects. What‘s important here is to have enough stars charted that there are plenty in every finder field.

(c.5) A planetarium computer program (Bill Arnett reminded me). If you are a beginning astronomer, I do **not** suggest you rush out and buy a computer, but if you already own one, you might bear in mind that there are programs that will turn your console into a window onto the simulated heavens, with features for finding, displaying, and identifying things. I happen to have the rather old Voyager 1.2 for my even older Macintosh II; there are plenty more, both for Macs and for the world of MS-DOS and its descendents. Some folks run such a program on a laptop, at the telescope. Please put red cellophane over your console, if you do.

I have had limited use for the popular oversize-format charts with lesser magnitude limits, like 7.5 to 8.5; they don‘t show enough stars to be useful with most of my finders, and are too cumbersome. The plastic-laminated versions make good place mats, though. Everyone should use the box of a Dobson as a picnic table at least once.

(d) A red flashlight, so you can read your charts and notes without ruining your night vision, or that of people near you. The kinds that have a red light-emitting diode (LED) instead of a flashlight bulb are particularly good. If other observers scream and throw things, your light is probably too bright.

(e) A logbook. This item is not for everyone, but I find it useful to record my observations, even if I don‘t do anything other than note that I saw a certain object with a certain telescope and magnification. Logbooks make fun reading when it is cold or cloudy, and often there will be reason to look up something long after the fact. Besides, if you quote frequently from your logbook, you can make your friends think you are an active observer when you really gave it up years ago.

What about observing skills?

Even some experienced amateur astronomers think that seeing things comes free and easy, with no more effort than opening your eyes: But as currently popular slang so evocatively articulates,

** NOT **.

Vision is an acquired skill. You must learn it, you must practice, and you must keep learning new things, and practicing them, too.

Buying a bigger telescope to see more is like buying a bigger kettle to be a better cook, or buying a bigger computer to be a better programmer. Not that it won‘t help—it might—but cooking and programming depend far more on knowledge and experience than on artifacts. So does visual astronomy. People with garages full of telescopes (pardon me while I try to close the door to mine) are in great part victims of materialism, marketeering, and hyperbole. Practice is cheaper, and works better. As I said near the beginning of this article, an experienced observer may see things with a small telescope that a beginner will miss with an instrument five times larger, even with objects and sky conditions that favor both equally. What skills may you hope to cultivate? What techniques should you practice? Not all have names, but here are a few, in what I think is order of importance; what matters most comes first.

(a) ***Patience***. It can take a long time to see everything in a field, even if you know exactly what you are looking for.

(b) ***Persistence.*** Eyes, telescope, and sky vary from night to night.

Dark adaptation. Avoid bright lights before observing: It takes your eyes hours to reach their full power of seeing faint objects.

(c) ***Averted vision***. The part of your retina that sees detail best, sees low light worst. Look „off to the side“ to find lumps in the dark. Many observers use averted vision on faint objects, but not for faint detail in bright ones. Detecting something doesn‘t mean you‘ve seen all you can. Don‘t let the dazzle of a galaxy‘s lens keep you from tracing spiral arms out beyond the width of the field. How about increasing magnification, and using averted vision to see if you can see more detail in the paler, but larger, image? Averted vision helps with double stars, when one star is much fainter than the other, even if the faint star is bright enough not to need averted vision if it were by itself. That is, averted vision seems to facilitate the detection of low contrasts as well as faint objects.

(d) ***Stray light avoidance***. Even when it‘s dark, background glow interferes with detecting faint objects. Keep it out of your telescope and out of your eyes. Try eye patches and eye cups for eyepieces. My first view of the Sculptor Dwarf Galaxy was with my jacket collar pulled up over my binocular eyepieces. I looked like a cross between the Headless Horseman and the Guns of Navaronne, but I saw the galaxy.

(e) ***Moving the telescope.*** The eye sometimes detects motion, or changing levels of brightness, more easily than static images. Jiggle the telescope, or move it back and forth, to make an object „pop out“. Try it while using averted vision.

(f) ***Not moving the telescope.*** The eye sometimes adds up photons over many seconds; if you can hold your eye still for a long time, faint things may appear. Try it with averted vision. (h) Respiratory and circulatory health. If you smoke, try taking a break before and during observing—carbon monoxide from incomplete combustion interferes with the ability of the blood to transport oxygen.

Clear sky, and enjoy your telescope. Jay Freeman freeman@netcom.com

3. What Does All the Jargon Mean?

OK, by popular request, here is a glossary of common astronomy terms encountered in amateur astronomy.

altazimuth mount

This is what you think of when you think of a tripod mount. It allows movement in two directions: parallel to the ground (azimuth), and at right angles to the ground (altitude). It is very useful for terrestrial observations, as it is a very natural way of observing. (Note: Dobsonian Telescopes are mounted this way)

aperture

The diameter of the objective.

Barlow

A Barlow lens is a device which has the effect of increasing the magnification. It does this by lengthening the effective focal length of the telescope you are using. Thus a 2x Barlow will double the magnification, a 3x will triple it. Barlows used to have a bad reputation, stemming largely from rather poor quality ones being sold. Modern Barlows are high quality and a good choice for expanding your collection of eyepieces. You should keep the Barlow in mind when buying eyepieces- buying a 3mm,6mm, 12mm, and a 24mm and a 2x Barlow is a very dumb idea. The only use you get from the Barlow is changing the 3mm to a 1.5mm (which is probably going to give you higher than usable magnification anyway). On the other hand, a 6mm, 9mm, 15mm and 24mm would be complemented very well by a 2x Barlow.

Binocular Telescope

A set of Dobsonian telescopes mounted so their eyepices form a Binocular 3D view of the sky.

catadioptric

Any of a number of compromise telescope designs, using both a lens and mirrors. Examples are the Schmidt-Cassegrain and Maksutov-Cassegrain. Because the light path is folded twice, the telescope is very compact. These are pretty expensive. Pictures can be seen in the ads in any issue of a popular astronomy magazine: the Meade 2080 and the Celestron C-8 are examples of Schmidt- Cassegrain; the Celestron C-90 and Questar are examples of Maksutov-Cassegrain. chromatic aberration In refractor telescopes, which use lenses to bend the light, different wavelengths of light bend at different angles. This means that the stars you see will usually have a blue/violet ring around them, as this light is bent more than the rest of the spectrum. It is not present at all in reflectors, nor to any significant degree in catadioptrics. Different glasses and crystals (notably fluorite) are sometimes used to compensate for the aberration. Such telescopes are termed „achromat," or „apochromat" if the correction is is nearly perfect.

collimation

This refers to how correctly the optics are pointing towards each other. If a telescope is out of collimation, you will not get as clear an image as you should. Refractors generally haved fixed optics, so you don‘t have to collimate them. Reflectors and catadioptrics usually have screws that you turn to collimate. (This only takes a few minutes to do- it is dead easy).

coma

This refers to the blurring of objects at the edge of the field of view, most common in short focal ratio Newtonian telescopes (at f/10 and longer, Newtonians are very well corrected for coma).

Dobsonian

Named for John Dobson of The San Francisco Sidewalk Astronomers (who prefers to call these „Sidewalk Telescopes"),this is a design which allows for very large apertures at very affordable prices. The trade-off is that they are mounted on altazimuth mounts, instead of equatorial ones, which makes them essentially useless for astrophotography, but an inexpensive alternative if you only plan to do visual work. These are light buckets. If you are planning to build your own telescope, you might want to consider a Dobsonian. Note: That this design is now the #1 Design seen at many Star partys.

equatorial

An equatorial mount is set to the current latitude, and is polar aligned (pointed at the North Pole in the Northern Hemisphere, the South Pole in the Southern Hemisphere) and then moves only in Right Ascension and in Declination. This take a while to get used to, but offers the wonderful side effect of being able to track the astronomical objects you are looking at as they move across the sky (which is very visible motion at telescopic magnifications) by moving in only one direction (Right Ascension). Most equatorial mounts come with motor drives that take care of this for you.

pupil exit

This refers to how wide the beam of light exiting the eyepiece is, and is equal to the aperture divided by the magnification. If it is bigger than the size of your pupil in the dark (7mm when you are young, 5 or 6mm when you are over 40, as a general rule) you will not be taking in all the light available- effectively, you will be using a smaller aperture telescope than you have.

eyepiece

This is the thing you actually look into. Almost all telescopes separate the Optical Tube (the telescope proper) from the eye piece. Essentially, the telescope makes a really tiny image of what it‘s pointed at. The eyepiece acts as a magnifying glass to allow you to see the image bigger than it would otherwise be. The magnification is the focal length of the telescope divided by the focal length of the eyepiece. Eyepieces are described by the diameter of the barrel, always expressed in inches (.965", 1.25" and 2" are the sizes in common use) and the focal length always expressed in millimeters (4mm - 40mm is the usual range). Short focal length eyepieces are also termed high power, long focal length are low power. Also significant with eyepieces is the apparent field of view (expressed in degrees) and eye relief (expressed in millimeters). The apparent field refers to how big the circle of space you see in an eyepiece appears. Bigger is better. Eye relief is a measure of how far from the eyepiece you can have your eye and still see. If you wear glasses to correct astigmatism, you will need fairly long eye relief (the focus knob will correct for almost all vision problems except astigmatism). There are several types of eyepiece designs. The most popular are Kellner (inexpensive, most popular for cheap telescopes, short eye relief and narrow fields of view. Good to avoid if you can afford better); Orthoscopic (good price/performance compromise); Erfle (wide field of view, expensive); Plossl (perhaps the best all-around eyepiece. Some moderately expensive versions available); and Ultra Wide (very expensive, almost double the number of lenses as other designs makes for more light loss in the eyepiece, large exit pupils. Can cost more than a small telescope. Not a good place to spend your money when you are just starting out). You really don‘t want to buy many .965“ eyepieces- they are generally not as well made as the 1.25“ ones, and if you get a bigger telescope it will probably not accept your .965“ eye pieces. You can buy an adapter to let you use 1.25“ in your .965“ focuser. This is probably worth the money.

f/10, f/6.3

See Focal Ratio

finder scope

The finder scope is a low power telescope attached to the telescope you are using. Because most telescopes show such a small portion of the sky, it is virtually impossible to locate anything just by looking through them. So you look through the finder scope to center the object you want (the finder has crosshairs) and then you can use your real telescope on it. Note that you can ignore all the claims about big finder scopes. You almost certainly don‘t care. All you need is to be able to point your main telescope at something in the sky. Finder scope size only matters when you are starhopping through fairly dim stars (where the larger aperture allows you to see dimmer stars). This will not be an issue for you for quite a while (if ever). Many people use a Telrad sight, which is simply a red LED you can sight on- you get absolutely no more aperture than your naked eye. The finder scopes are usually advertised as 8x50 (or such). The eight refers to the magnification, the 50 to the aperture in millimeters-just like binoculars.

focal length

This is the length of the light path, from the objective to the focal plane. The magnification is the focal length of the telescope divided by the focal length of the eyepiece. See also focal ratio.

focal plane

The plane that the telescope (or eyepiece) focuses on. When you turn the focus knob on the telescope, you are moving the eyepiece back and forth until you make the two focal planes coincide.

focal ratio

Also referred to as the „speed“ of the telescope, is the ratio of focal length to aperture, and is always expressed as an f/number. Thus an 8“ telescope with a 2000mm focal length is f/10 (because 8“ is 200mm, and 2000 / 200 = 10). An f/10 telescope is „slower“ than an f/4. Fast telescopes give wider, brighter images with a given eyepiece than slower ones (but note that at a given magnification, the images are-assuming identical optics-exactly the same: what you see through a f/6.3 telescope with a 12mm eyepiece is identical in width and brightness to what you would see through a f/10 telescope with a 19mm eyepiece). In general, the slower the telescope the more forgiving it is of optical errors in the objective and eyepiece. A telescope of f/10 is fairly forgiving, f/6.3 much less so.

focuser

This is the thing that holds the eyepiece. It moves in and out so you can focus the telescope. It is always included with the telescope when you buy one. The size, almost always .965“, 1.25“ or 2“ refers to the barrel diameter of the eyepieces it accepts.

fork mount

A fork mount is a type of mount where the telescope is held by two arms, and swings between them. A fork mount can be either alt-azimuth or equatorial (through the use of a wedge). Fork mounts are most commonly used with Schmidt-Cassegrain telescopes, and are almost always equatorial.

German Equatorial Mount

The first equatorial mount devised and still the most common for small to moderate sized reflectors and refractors. Unlike the equatorial fork, the german equatorial is suitable for telescopes with either short or long tubes (although, if poorly designed, a long tube may strike the tripod, preventing viewing at the zenith). They usually are designed with movable counterweights, which make them easy to balance, but heavy and bulky. The tube of the telescope is joined to a shaft (the Declination shaft or axis) which rotates in a housing that in turn is joined at right angles to another shaft (The polar axis). The polar axis is pointed at the celestial pole (just like any other equatorial mount). A counterweight, which is required for balance, is placed on the other end of the decination shaft. Tracking an object past the zenith requires that the telescope be turned (both Right Ascension and Declination rotated through 180 degrees), which reverses the field of view. Not so much a problem for visual astronomy, but a limitation on astrophotography.

light bucket

A common slang term for a large aperture. The cure for „Aperture Fever.

Maksutov-Cassegrain

See catadioptric.

Meridian

An imaginary north/south line passing through the zenith.

Newtonian

See reflector.

objective

This is the thing that gathers light from the sky and folds the light into a cone. In a refractor it is the big lens that points at the sky, in a reflector it is the big mirror at the bottom of the tube. The job of the objective is to create a light cone which comes into tight focus at a single focal point.

optical tube

This is the telescope proper. It is the tube which holds the objective. The rest of the stuff are accessories, such as the mount, tripod, and eyepieces. When reading ads, note that some times optical tubes are sold by themselves. You will need to go out and buy (or build) a mount for them before you can use them.

reflector

A reflector is any telescope which uses a mirror as its objective. The most common type is the Newtonian reflector, which has a mirror at the bottom of a tube, which focuses the light into a cone which is deflected by a flat „secondary“ mirror (which is mounted near the top of the tube in something called a „spider“) out a hole in the side. This is where you put the eyepiece. The advantages of the Newtonian design are numerous: there is only one optical surface on a mirror, as opposed to two on a lens, so it is cheaper to make; part of the light path is at right angles to the length of the tube, so it can be somewhat shorter than a similar refractor; you can get it in much larger apertures than a refractor, and there is no chromatic aberration .

refractor

This is what you usually think of as a telescope- it has a lens at one end, and you look straight through the other. This is sometimes referred to as a „Galilean“ telescope, as it is of the same design that Galileo used (although strictly speaking, a Galilean telescope is a specific kind of refractor- one with a simple double-convex objective lens and a simple double-concave eye lens.

right ascension

See declination.

Schmidt-Cassegrain

See catadioptric.

spherical aberration

A problem where a lens or mirror in a telescope is not shaped correctly, so the light from the center is focused at a different location than the light from the edges. You should never have to worry about this. This only shows up in really cheap telescopes.

spotting scope

A small telescope, always a refractor or catadioptric, generally used for terrestrial viewing. Of limited utility for astronomy, though many are marketed as such. Probably the wrong choice unless you want to use it also for birdwatching, or as a powerful telephoto lens on a SLR camera.
wedge
This is the thing that a fork-mounted Schmidt-Cassegrain tele- scope will attach to, to connect it to the tripod. You want it to be sturdy.

worm drive

This is the sort of drive most telescopes come with, if they come with a drive. It is a very accurate and smooth drive. However, due to imperfections in the manufacturing process, there will be periodic errors that occur at the same point in every worm cycle (usually about 8 minutes). To deal with this, higher end telescopes come with drives which compensate for the mechanical defects.

zenith
The sky directly overhead. An object „transits" when its line of right ascension crosses the zenith.

4. What Are Some Good Introductions To Amateur Astronomy?

In the United States, there are two popular astronomy magazines*: Sky and Telescope* (S&T), and *Astronomy*. Of the two, S&T is more technical, while Astronomy has more things like „artist‘s conception of Jupiter-rise on Ganymede" which are very pretty. I consider S&T a necessity, but getting both is not a bad idea.

P. Clay Sherrod‘s *A Complete Guide to Amateur Astronomy*,available through Sky Publishing Company, is a more technical introduction.

Sidgewick‘s books are absolutely excellent books,probably the very best ever written on amateur astronomy.

Nightwatch by Terence Dickinson is a good introductory book on Astronomy. Great section on purchasing a telescope. Star charts are so-so.

The Backyard Astronomer‘s Guide by Terence Dickinson and Alan Dyer. A comprehensive introduction to astronomy and the equipment amateurs like to use. Written by and for amateur astronomers.

Also see below, the section on Books and Starcharts.

5. What Will I Be Able To See?

The best way to find out is to go observing with someone. Look for a local astronomy club (S&T lists them periodically). This is also a very good way to get a good price on a used telescope of proven quality.

In general, you will be able to see all planets except Pluto as disks.You will be able to see the bands and Red Spot on Jupiter and the rings around Saturn. You may be able to see the ice caps on Mars (although Mars is probably the most disappointing object in the Solar System). Venus and Mercury will show phases but not much else.

You will be able to see four of Jupiter‘s moons as points. Ditto Saturn‘s moon Titan. You will be able to see comets.

Do not expect your images to be anywhere as nice as the ones you see from the Voyager spacecraft. If a $2000 telescope could get these, nobody would have spent billions of dollars to send a spacecraft out there.

As far as „deep sky" objects, you will be able to see all the Messier objects in most any modern telescope. Galaxies will tend to look like bright blobs. Look a while longer and you may find some spiral arms or dust lanes (assuming it has them). Galaxies look nothing like their pictures - you will not see the arms anywhere near as clearly.

You will also find that the colors you see are considerably more muted than the pictures you see. This is because our retinas work by having two different types of light sensitive organs, rods and cones. Rods are very sensitive to dim light, but relatively useless for color vision. Cones are the opposite. Thus when looking through a telescope you are using your rods,and you aren‘t seeing a lot of color.

6. Buying A Telescope

6.1. What Company Makes the Best Telescopes?

This is a very unfair question at the best. There are many companys which make good telescopes. A lot will depend on just how much you want to spend for a telescope. The Major companys that make and/or sell telescopes are as follows: **Orion Telescopes, Meade, and Celestron**, but you have to be carefull with what you buy from even these companys,as they ALL are selling telescopes which are coming from Prison factorys in ‚RED CHINA‘ and are the same as the Junk department store telescopes. There are other smaller companys that make good scopes too. There are some Japanese companys that are selling some very good telescopes and also some poor ones too. **Televue** has a very good reputation, at a somewhat higher price. **Tasco** is sold at Toys R Us, K-Mart, & Wal-Mart,etc. Waste of Money. Notice: Tasco has taken over Celestron, they are now one company, only time will tell if this inproves Tasco or Degrades Celestron.

Simmons: Total waste of money, worst than Tasco.

Bushnell: I have looked at this companys telescopes 1st hand and I do not belive that they would withstand one full night of useage viewing the sky. They are even WORST than Simmons! They are so bad they make Tasco junk look good!
There are now a lot of smaller companys poping up that are selling the same ‚*Made in Red China*‘ telescopes uder names never seen before it would be a good idea to stay away from them too.

There are some companys importing *telescopes from Russia*, I have not seen these scopes first hand, but have read some good reports of them.

6.2. What Is The Best Telescope To Buy?

Once more this will depend on the answers of questions you need to ask yourself. Are you going to use the telescope for just viewing? or are you going to into the field of Astrophotography? Also it will depend on how much you want to spend too. In the end,only YOU can answer this question.

No FAQ list is going to be truly definitive - we all have our own opinions and interests, and one person‘s „piece-of-junk optics“ might be another person‘s dream telecope. This does not apply to department store telescope, though. Really.

As the numbers of companys who now either make and/or just sell Telescopes of ALL price ranges, the list is just to much to put into this FAQ, instead, the next section will list a number of both large and small companys that market telescopes. The best idea would be to contact the comapnys and find out what kind of telescope they market in your price range. Then if you can, Find one of those telescopes at a Star party.

7. OK, Where Do I Buy My Telescope?

Well, there are three basic places:

A Store
Yes, the obvious-you find a store (NOT a department store) which sells telescopes and write a check (or, if they won‘t give you a cash discount, use a credit card that offers buyer protection, or gives you bonus miles, or some such).

The advantages of this method is that you have someplace to return the telescope to if you have problems with it. Some places even offer your money back if you change your mind within some grace period.

The disadvantage is that you generally pay more for the telescope itself, and you pay sales tax.

Mail Order
There are two sorts of mail order: the discount stores that sell all sorts of stuff through the mail, and telescope stores that sell through the mail in addition to selling from their store.

The advantages and disadvantages of mail order are obvious: you cannot take the merchandise back easily if something goes wrong, but it‘s cheaper and you probably pay no sales tax.

Other People
You can find some great deals in used telescopes. Many people buy expensive telescopes, use them two or three times, get bored and sell them. The advantage is strictly monetary: you pay significantly less (and,of course, no tax).

The disadvantage is that you are buying something „as is“ which you may want to think twice about doing if you are buying an expensive telescope. Also, both Meade and Celestron offer (limited) lifetime warranties on their optics, which are not transferable.

All that having been said, here is a list of places you can buy telescopes, with comments as applicable. Note that not all will sell or will ship. To you, some you must go to a store.

Orion Telescopes
P.O. Box 1158\par
Santa Cruz, CA 95061
(also San Francisco and Cupertino)
800-447-1001
sales@oriontel.com

Orion Telescopes carries a wide selection of binoculars, telescopes, and accessories (Celestron, Tele Vue, and their house brand; they do not carry Meade). They have a 30 day „no questions, satisfaction guaranteed“ refund policy, which they do seem serious about. A fair number of people (myself included) have bought at Orion and all are very satisfied with the way they were treated. If you need technical assistance when you call, ask for Steve or Eric. They have a very good service and support record.

Lumicon
2111 Research Dr. #5
Livermore,Ca.94550
While I have not had any dealings with this company,the messages I‘ve seen on sci.astro.am have all had good things to say about them.

Astronomics
2401 Tee Circle Suites 105/106
Norman, OK 73069
Higher prices than Adorama and Focus (see below),but lower than Orion and Lumicon. Enthusiastically recommended by a couple of people on the net. As with all mail order, make sure the shipping price is included.

Celestron International/TASCO.
2835 Columbia St.
Torrance,Ca.90503
This company also sells many types of telescopes. From SCT‘s to DOBs. Have seen both Good and Bad posted about them. As Noted above this company is now owned by TASCO.

Mag 1 Instruments
16342 Coachlight Dr.
new Berlin,Wi.53151
Markets their ‚Portaball‘ style DOBs in 8in and 12.5in size.

Mead Instruments Corps.
6001 Oak Canyon
Irvine,Ca.92620
Markets many types of Telescopes, from junk to High End.

Coulter Optical
Div. of Murnaghan Instruments
1781 Primrose Ln.
West Palm Beach,Fl.33414
They market a full line of DOBs.

Obsession Telescopes
P.O.Box 804a
Lake Mills,Wi.53551
Markets Dob‘s from 15in to 30in!

Pocono Mountain Optics
104 N.Plaza

Moscow,Pa.18444
Enthusiastically recommended by a few people on the net. Owned by Glenn Jacobs who goes to most of the astronomy get-togethers in the NY-NJ-PA-CT area so you actually meet him if you live in the area. Often willing to cut a package deal if you are buying big ticket items. No problems returning things with which you are dissatisfied.

Roger Tuthill
11 Tanglewood Lane
Dept. ST
Mountainside,N.J. 07092
Enthusiastically recommended by a person on the net. Not the least expensive, but top-notch service. Roger unpacks, inspects and collimates every scope he sells, and is very good about refunding your money if you are dissatisfied.

Stargazer Steve
1752 Rutherglen Cr.
Sudbury, Ontario
P3A 2K3 Canada
Markets a 4 1/4inch DOB in both Kit form and/or ready-to-use. Both under $300.00. Also a 6inch DOB kit for under $450.00 with shipping.

Starsplitter Telescopes
3228 Rikkard Dr.
Thousand Oaks,Ca.91362
Markets DOBs from 8in to 30in.

University Optics
P.O.Box 1205
Ann Arbor,Mi.48106
A few people have reported using University Optics, and all report receiving good service. I have heard no complaints.

Parks Optical
270 Easy St.
Simi Vally,Ca.93065
A couple of people have mentioned that shipment can be pretty delayed,but the quality of their equipment appears to be high, and improving. Salespeople vary from knowledgeble to bubbleheaded.

Adorama
42 West 18th Street
New York, NY 10011
orders: (800) 223-2500
info: (212) 741-0052
Along with Focus Camera (see below), the lowest prices you will find. Expect no dealer support, and make sure you find out how much they will charge for shipping before placing your order. And pray that the optics arrive intact. I really would recommend that you not buy telescopes from these guys. Eyepieces and other accessories, however, are probably worth the risk if the price difference is significant.

Focus Camera
4419-21 13th Avenue
Brooklyn, NY 11219
orders: (800) 221-0828
info: (718) 436-1518
Refer to Adorama. Same comments apply.

Pauli‘s Wholesale Optical
Danbury, CT
A lot of bad reports, order at your own risk!

Also there is the AstroMall.

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**                                                                **
**            A S T R O - M A L L                                 **
**                                                                **
**   ONE STOP ASTRONOMY SHOPPING AND PRODUCT INFORMATION          **
**                                                                **
** See in-depth product information for such companies and        **
** products as:                                                   **
**                                                                **
** Tele Vue Optics, Edwin Hirsch, Spectra Astro-Systems,          **
** Lumicon, Software Bisque, Astro-Cards, Astronomical            **
** Adventures, Bethany Sciences, Equatorial Platforms,            **
** Jim Kendrick Studio, Science Software, Celestial Products,     **
** Gnome Technologies, Custom Ophthalmics, Analytical             **
** Scientific, Galactic Images, Murnaghan Instruments, Crazy      **
** Ed Optical, Celestial Scripts, Deepsky 2000 and more...        **
**                                                                **
**          http://www.rahul.net/Astro-Mall                       **
**      ftp://ftp.rahul.net/pub/resource/products                 **
**   or e-mail resource@resource-intl.com and request             **
**   AstroMall.txt for current information request form          **
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2. What About Building A Telescope?

This section was written by Andy Michael.

We just took a rather unusual approach to getting a beginning telescope: we took John Dobson‘s telescope building class and built an 8“and a 12.5“ reflector on Dobsonian mounts (of course). We went this way for a few reasons: to get large aperture for seeing deep sky objects and higher magnification with good resolution when compared to small refractors in this price range, to keep the price down, and to soak up John‘s wit and wisdom. The down side is that these telescopes are not suited for astro-photography (at least not without building a different mount) but that didn‘t bother us. Also they are large. The 8“ tube we broke into two pieces for easy portability, but the 12.5“ one will probably go on the roof rack. These are about f/7 telescopes so the tube lengths are 56“ and 7‘ respectively. Of course, when you build yours you can make whatever size you want. On the other hand you can pack your clothes in them; try that with an SCT. The cost was about $250 for the 8“ telescope, $450 for the 12.5“er plus about 24 to 30 hours of work and 16 - 24 hours of class. It‘s a challenging project but the first time you focus on something with a mirror you ground is an incredible thrill. Another benefit is that we now know a lot about telescope design and if we ever have problems with them we know how to fix them.

If you don‘t have access to John‘s (or other peoples) classes then you can try building one by reading his book and by watching the video. Our class was the first to see parts of the video and had great success at finishing the telescopes fast and without needing to correct the mirrors very much. Coincidence? Class consensus was no. The book (excerpted from the order form): „How and Why to Make a User-Friendly Sidewalk Telescope“ by John Dobson with Norm Sperling.To appreciate why Dobson makes each factor just so, learn how he thinks about it. His philosophy of star-gazing perfuses his telescopes and his book. The book includes the only detailed biography;wonderful vignettes from the Sidewalk Astronomers‘many expeditions;their own special way of describing celestial objects; and, of course,complete details for making a Dobsonian. 169 pages; 154 clear,friendly line drawings; 9 photos. Hardbound in plywood, Dobson‘s favorite material. Exclusive source. Send $39.95 + $5.00 shipping to Everything in the Universe, 185 John Street, Oakland, CA 94611.
The video (also excerpted from the order form): For the first time on video, John Dobson shows how you can build your own low-cost Dobsonian Telescope. The 90-minute video is a complete step-by-step guide, covering telescopes from 8 inches to 16 inches in diameter. $39.95 +$3.50 shipping.

7.3 What is the Best Mount?

EQUATORIALS Vs. ALTAZIMUTHS: THE TRUTH

The various telescope mounting systems available for use by amateur astronomers have been discussed at length on sci.astro.amateur. There has been a great deal of debate, a little ill-informed opinion, and some real misconceptions concerning each of the basic mounting schemes, so perhaps it is time to clear the air. One basic and irrefutable fact must be stated up front: NO MOUNT SYSTEM IS PERFECT FOR ALL SITUATIONS! Any attempt to champion one mount scheme over another without considering all the facts is doomed to failure. Below are the true advantages and difficulties of the two most popular mounting sytstem.

The ALTAZIMUTH (ie: Dobsonian, ect.).

This mounting systém has gained considerable popularity over the past 20 years, evolving from the old „pillar and claw“ system originally used only in inexpensive small telescopes, to a modern well-designed one which boasts of supporting some of the largest apertures in amateur astronomy today.

Altazimuth Advantages:

1. Simple and stable mounting system requiring no axis counterweights or heavy off-center concentrations of weight to induce vibration or mount flexure problems. Only two vertical and one horizontal bearings are needed.
2.

2. Easy and intuitive mount for beginners to learn on.
3. More portable than many equatorial mounting schemes, especially for apertures over eight inches (often faster setup time).
4. Easy to build, and often allows simpler mirror-support schemes to be used.
5. Lower overall cost, especially for large apertures.

Altazimuth Disadvantages-:

1. Unable to track objects with single axis motor drive system. For long term tracking, an altazimuth must be computer dual-axis controlled, or supported on an equatorial platform (only 1.25hrs maximum tracking time on such a platform). Cannot track objects directly through the zenith in dual axis driven mode („Dobson‘s“ hole).
2. Lack of fixed field orientation makes star hopping the primary mode of faint object location in non-computerized altazimuth mounts (right-angle sweep and R.A./Dec. Setting circles cannot be used). Objects not located in easy-to recognize starfields can be more difficult to find manually.
3. Changing altitude and azimuth coordinates can make finding objects more difficult using only altitude and azimuth circles, often requiring computer readouts or nearly continuous manual calculations to keep track of pointing directions for locating objects.
4. Field rotation limits photography to short exposures (unless expensive field de-rotators are used). Guiding long exposures can be very difficult,since corrections for drift are sometimes non-intuitive.

EQUATORIAL MOUNTS:

These mounts are aligned to the celestial coordinate system, and have been the mainstay of serious amateur and professional astronomical telescopes for over a century. They come in a variety of designs: German Equatorial, English Yoke, English Cross-axis, Polar disk, Fork, Split Ring, ect.

Equatorial Advantages:

Can use one „clock-drive“ motor to drive the telescope in right ascension for long-term tracking of celestial objects.

1. Most equatorial schemes (except for Yoke mount) can reach and track through all areas of the sky.

2. No field rotation enables easier long-exposure photography with more intuitive guiding corrections. Also makes planetary observations a bit easier, since the object in the field does not rotate.

3. Finding techniques such as the „right-angle sweep“ or star drift method can be used to make locating faint objects easier and faster, even with non-clock driven scopes (only one nearby visible reference star is needed).
4. R.A./Dec. Setting circles (both digital and analog) can be used for locating non-visible objects. Digital circle design for equatorial scopes can be simpler, since no real-time guiding calculations need to be performed.

Equatorial Disadvantages-:

1. Good Equatorial mountings tend to be bulky and heavy, making them less portable than some altazimuth designs (often have to be broken down into many smaller components for transport).
2. German Equatorial mount requires heavy counterweight on a long shaft to make the scope balance. This can be a problem in the dark with people running into them. German Equatorial mounts can also have problems with the scope running into the pedestal for some objects near the zenith, requiring a „roll over“ reversal for continued tracking.
3. Moment arms of equatorial mounts tend to allow flexure and vibration to become problems unless the mount is heavily overbuilt. Fork mount tines tend to flex, making for mild tracking errors and periodic lower-frequency „pogo“ oscillation vibration problems with heavy scopes and longer tine length.
4. Good Equatorial mounts usually have four bearings, and can often be more expensive than altazimuth mountings (they can still be home built, however).
5. Proper polar alignment is necessary for accurate tracking.
6. 6.Less intuitive for beginning amateurs, although once the amateur gets used to them, the amateur can often find and track objects faster and more easily than with altazimuth mountings.

NOTE: none of these disadvantages will eliminate a mount design from use by the amateur. For strictly visual use (especially for the beginner), the altazimuth can easily be recommended, while for long-exposure photography, the equatorial is often the mount of choice. For very large apertures intended for easy portability, the altazimuth almost has to be used. However, the compact split-ring equatorial design can also remain fairly portable even with telescopes as large as 18 inches. Computers and computerized driving systems have narrowed the choice between the two mounting systems (and driven up their prices), but their basic characteristics have not changed. In any case, both the altazimuth and the equatorial have a firm place in amateur astronomy.

David Knisely

7.4 Binocular Telescopes

There have been some people who have built their own Binocular Telescope, this is two telescopes who are the same in every way that are mounted together and are used more or less like a pair of binoculers but are much more powerfull. During the last few years a bino viewer has been made that turns a normal scope into a bino-scope.

Now there is at lest one company that is making and selling their own Binocular Telescope. While I have not been able to use such a scope (I don‘t have that kind of money!), I would think that the images from it would be awesome!

SanJO Instruments
1157 Bucke St.
London, Ontario, Canada
N5Y 3S2
http://www.execulink.com/~sanjo

8. What Accessories Will I Need?

In addition to a telescope, you absolutely must have a mounting and a tripod. You will also need a few eyepieces, a telescope with only one eyepiece is like a piano with one key.

These accessories don't come cheap, expect to pay as much for the mounting and tripod as you paid for the optical tube. For a first telescope,you probably will want to buy an entire system it tends to be less expensive that way.

Which eyepieces should you start with? I'd suggest three or four, maybe a 30mm, 25mm, 20mm, 8mm and a 2x Barlow (which will give you coverage of 30,25, 20, 15, 12.5, 10, 8, and 4 mm). Buy eyepieces of like quality to your telescope. Putting a $300 Nagler eyepiece on a $150 telescope is pointless (it would also probably tip over the entire telescope).

9. What Are Digital Setting Circles

This section was written by Jim Van Nuland

9.1. What Are They?

Digital Setting Circles (DSCs) are a small special purpose computer, mounted on or near a telescope. The scope has shaft encoders attached to sense the motion of the scope's axes, and the computer then converts these motions to the position of the telescope, and displays it (for instance) in Right Ascension (RA) and Declination.

An 8-conductor cable runs from the computer to the encoders, with 4 wires to each encoder. RJ-45 telephone connectors are used at the computer. They do NOT move the scope. You push it by hand, and the DSCs tell you which way to move and how much.

What makes DSCs so desirable is that they work on alt/az-mounted scopes; and even with equatorial mountings, it is not necessary to polar align the mount. (However, it's desirable to have the mount at least roughly polar-aligned so it follows an object.) Additionally, most models have an internal catalog and a „guide" mode.One selects an object (or, in some,a planet), and the DSCs tell which way to move each axis.

They are marketed by Lumicon, Jim's Mobile, Inc., Celestron, and Orion Telescope Centers. The various brands and models differ mostly in their internal catalogs of celestial objects. All are actually manufactured by the same company, Tangent Instruments of Palo Alto, California, USA, who, however does not sell directly to individuals. I own the NGC-MAX from JMI, so some of my statements may not apply to other versions.

9.2. Must the ground board be leveled?

No. An alt/az mount must have a fiduciary mark such that the tube can be placed accurately at 90 degrees to the elevation axis. One way to do this is to (one time only) level the ground board, then the tube. Make the mark in such a manner that it can be adjusted when something changes. Some models of DSCs allow an alt/az mount to be initialized in a vertical position. When starting the DSCs, the tube must be set horizontal (or vertical), and then two stars are used to align. The stars must be at least 20 degrees apart in the sky (90 is ideal), and the first may not be Polaris.

9.3. How does one set up an equatorial mounting?

If the mount is known to be accurately polar aligned, you may still use two stars as mentioned above. Or you may set the DSCs to také advantage of the known alignment, and it will require only one object,and no zero degree reference mark is needed. If an equatorial mount is not polar aligned, it must have a reference mark at zero degrees declination, and must use the two-star setup. For a German mount, the mark may be on either side of the scope (tube pointing east or west), and the DSCs set to correspond. The mount may be driven or undriven. As for an alt/az mount, the stars must be at least 20 degrees apart, and the first may not be Polaris.

9.4. Do the DSCs support a Poncet platform?

Probably depends on the model. The NGC-MAX provides telescope type ET(equatorial table). It assumes that the table is carrying an alt/az scope, and that the scope is initialized with the tube horizontal. I believe that an equatorial mount could be used, but have not tried to simulate it.

9.5. How accurate is the device?

The position of the scope is displayed to one minute of RA and 10 minutes of dec. Guide mode displays position error to 0.1 degree of arc. The actual accuracy depends on the care with which the alignment was done, the accuracy of the mounting, accuracy with which the shaft encoders were installed, the resolution of the encoders, and a bit of luck. If the level or zero was not set accurately, the system will work poorly, and it should be re-started. If star settings were done carelessly, one can simply re-do one or both of them. The „luck“ factor stems from the digital nature of the shaft encoders. If the encoder is on the verge of a step, you could be off by one step.

The absolute theoretical resolution is three encoder steps, assuming everything else is perfect. In practice, I get about 0.2 to 0.3 degrees, and closer near the alignment stars. If I move a long way across the sky, the error is perhaps 0.5, but then I re-align on a convenient nearby star. It‘s not too unusual to get 0.1 if all has gone especially well during alignment. This with 4000 step encoders.

Accuracy is best between the alignment stars, and the DSCs calculate a „warp“ so as to spread out the error. When re-aligning, only one star sighting is needed. The DSCs retain only the two most-recent star settings, provided they are at least 20 degrees apart in the sky.

9.6. What objects are in the internal catalog?

This is the major difference between models. All have a few dozen named stars, used especially for initial alignment. Some have the planets. The Lumicon models have a catalog of planetary nebulae, which is Dr. Jack Marling‘s specialty.

The NGC-MAX version 3.94 (July, 1992) has the planets;28 user defined objects; the Messier catalog (including M40 and M110); the full NGC,including the so-called „non-existent“ objects; about half of the IC catalog; a catalog of 951 interesting stars (multiple, red, variable);and a list of 367 additional deep-sky objects, many of which are very faint.
For each object, the catalog has the position, magnitude, size (diameter or separation), constellation, name (if any) and/or catalog number, and the type of object. Some have a word or two of description. This probably varies with the brand and model.

9.7. May I add my own objects? Comets, for instance?

The NGC-MAX accepts user objects, and I presume most other high-end models do as well. I like to put in the Sun and Moon, so that I can align during the day. This must be done carefully, with the Sun filter attached. THIS IS DANGEROUS, as the filter must be removed when sighting on the Moon, and if you come back to the Sun, you MUST have first re-attached the filter! The moon is a poor alignment object because it has up to a degree of parallax, and it moves about 0.5 degrees per hour. But it provides a start, and it may be enough to locate some bright stars, and re-align.

9.8. What is „identify“ mode?

Identify mode is present in the NGC-MAX, and probably other models. One specifies the class of object, and the faintest magnitude, then the DSC selects the nearest to the telescope‘s position. Very nice, but in the Realm of Galaxies, alignment is critical and then there are too many to be certain. To check, read out the magnitude and description, and go to Guide mode and see how far away the object is. It‘s especially useful in clouds, as one may point the scope into a clear spot, then ask what is nearby. One must separately search for galaxies, clusters, etc. Identify mode runs continuously, so that, as the scope is moved, the DSCs will (after a few seconds), indicate the new (or nearest) object. Some models allow alignment on ANY catalog object, which is helpful, but I find that accuracy is best on stars or very round objects. I find that planetary positions are especially suspect. The computer carries only the date, not the hour. (Use UT date.) I have often had poor alignments when using planets, and do so only for daylight set-ups; I re-align on stars as soon as I can find any. Open clusters are especially unreliable; galaxies are not much better.

Jim Van Nuland, San Jose (California) Astronomical Association

9.9. Can it replace star charts?

For comparatively easy objects, probably. In a crowded field, no.Some models support the Tiron Atlas 2000 and the Uranometria 2000, by indicating, for each object, the page on which it (the object) will be found. These models also indicate the chart corresponding to the position of the scope, regardless of specific object.

9.10. What other functions are present?

This varies heavily with model. The NGC-MAX (here we go again) has two that have not already been discussed.

„Timer“ counts up in hours, minutes, and seconds. It can be stopped,reset, and re-started, but can‘t be restarted without first being reset.

„Encoder“ shows the encoder positions in degrees. If an alt/az scope was pointed north when the DSC was powered up, then encoder mode will read elevation and azimuth, if the scope is also standing reasonably level.

9.11. How is it powered? How long does the battery last?

There is an internal 9-volt transistor battery. The load is 18 to 40mA (NGC-MAX), depending on how bright the display is. I suppose this might depend on the model, too. The maker claims 30 to 50 hours on an alkaline battery. They do last a good long time. There is a „low battery“ indicator which would turn on at about 4.5 volts, but in practice, I get „encoder error“ messages before that.

Some models have a second connector (serial port) by which external 9- 15 volts DC may be supplied. This does not require the internal battery to be removed; the two supplies are in parallel with diodes to prevent back-circuits. It does not recharge the internal battery.

9.12. How accurately SHOULD the mount be constructed?

The brief answer is, as accurately as you‘d like the DSCs to operate.For an equatorial mount, there must be little flexure; the RA axis must be perpendicular to the dec axis, which in turn must be perpendicular to the optical axis of the tube.

For an alt/az mount, the ground board must be rigid, the azimuth bearing surface must be flat, dent-free and stiff; and the side bearings must be the identical height, that is, the elevation and azimuth axes must be accurately perpendicular. In addition, the optical axis of the tube must be perpendicular to the elevation axis. There is a terrible irony here: the Dobsonian mount works precisely because its kinematically stable design does NOT require that it be accurately constructed!

9.13. How accurately should encoders be installed?

Again, the short answer is, as accurately as you‘d like the DSCs to operate. One can‘t do the job with a hand-held drill. OTOH, careful work with a modest lathe and drill press is quite sufficient, especially if performed by a modest machinist. Most astronomy clubs have such a person.

Best accuracy is obtained with high-resolution encoders. Standard encoders have 2048 steps per revolution, and high-res type has 4000.One can also use gears to provide greater resolution, but see below.

If the encoder is connected directly to a shaft, the hole in the shaft must not be oversize. It must be straight, well centered, and parallel to the axis. The body of the encoder must be held so that it cannot rotate with the shaft. If it is connected by gears, the shafts must be parallel, and there must be no backlash.

Encoders are not especially delicate, but they do not like to be bent.They require very little torque, and rotate continuously. The setscrew should not deform the shaft. The 4-wire connector should be looped so it does not pull on the encoder. They may be mounted such that the shaft is stationary, with the body moving, or the usual way;the direction is set in the DSCs‘ setup option.

In an alt/az mount, the azimuth encoder is typically mounted atop the center bolt. In this case, the bolt must be nicely perpendicular to the ground board, and the comments about shaft mounting (above) apply. If the rocker box has any side play, it will be nearly impossible to avoid some runout. This can be reduced by using a very long lever arm to hold the body of the encoder.

Both side bearings must be round (especially the one with the encoder), the center must be carefully located, and the encoder shaft parallel to the elevation axis. Any runout There will cause serious inaccuracies when moving across the sky.

9.14. How accurately MUST the mount be constructed?

Please don‘t feel that only a million dollar mount can be equipped with DSCs. My 1972 Optical Craftsman (German) mount works very well,even with about 0.5 degrees of error if I shift the mounting and return to an object. This was the economy model! A machinist friend helped me drill the holes for the encoder shafts. I used UGMA grade 10 precision gears to step up the dec shaft speed. The designer of the DSCs was amazed at that, and admitted that he used UGMA 4 with adequate results. I don‘t know how to calculate how much more accuracy I might be getting from my expensive gears. My alt/az mount, crafted of wood in my shop with only hand tools, carries a 108mm f/4 scope, and **always** puts an object in a low-power field. OTOH, if I re-collimate the scope, I must also re-position the vertical mark. I usually re-align after moving far across the sky. If the mounting is less than perfect, it means that you will need tore-align more often. But if the mount is **really** sloppy, it probably will not be satisfactory.

9.15. Can I connect the DSCs to my own computer?

Yes, for some models. The NGC-MAX, and probably others,has a serial port that may be used with an external computer, so that the screen shows a dynamic star map, identifies objects, etc.

But the attached computer must take over ALL functions, including the prompting for „level me," pointing at particular alignment stars,guiding, calculating the conversions for RA and Dec, etc. I understand The_Sky, from Software Bisque, does all this, but I have not seen it in use nor heard from a live user. The port is a modular telephone connector (RJ11). It has four wires:B+, data in, data out, and ground. External to the NGC-MAX, the cable must route DTR back to the attached computer as DSR, CD, and/or CTS,as needed by the attached computer. The 4th wire is +Battery, a 9 to 15 volt external power supply, which does not charge the internal battery. It is not necessary to remove the internal battery,

When the NGC-MAX is operating in „BOX" mode, it blanks its own display, and does nothing but pass the shaft encoders‘ values over the serial port. It multiplies them by the encoder ratios (the latter set in the NGC-MAX setup function), and scales them such that 00000 is the position at power-on, and 32767 is just under 1 rotation.

Communication is at 9600,8,N,1. When the NGC-MAX powers on, it sends a hello message such as „V2.94“. When the attached computer sends a character (the sample program uses „Q“ but anything seems to work) down the port; and the NGC-MAX replies with 13 characters of the format „+00000t+00000“ where the „t“ is ASCII 9, and the 00000s are the two encoder values.

I don‘t use this facility, but I‘m too curious not to have tried it.I used my modem program to supply the computer side. I use the NGC-MAX whenever I‘m doing general observing, and I like it very well.But I don‘t have a portable computer to use with it, and don‘t too much see the need. OTOH, if I fell into a laptop, I‘d surely want to try connecting them.

10. Why Should I Start With Binoculars?

The quick answer is because you already have them, so you do not have to spend any money. Certainly going right out and buying the Fujinon 25x150 Astronomical Binocular ($11,000 list price) would be a pretty stupid thing to do, no matter how good the binoculars are. You should also avoid the quick-focus binoculars, as they are easy to de-focus as well.

The remainder of this section was written by Paul Zander.

Based on my experience, I suggest that you start with a pair of 7x50 binoculars. This is the most popular size and hence good ones are available from many stores, even some of the discounters. Be sure to get ones that have anti-reflection coatings on the mirrors and lens. If you wear eyeglasses, you may be able to find binoculars which can focus without them (unless you have significant astigmatism). Make sure the image is sharp at the center and edges at the same time.

„7x“ is the magnification. Most people can hand hold these without needing to bother with tripods, etc. The „50“ means 50mm (~2 inch) objectives (aperture). This gives light gathering ability similar to many small telescopes. Many advanced star gazers regularly use binoculars to either locate items to focus telescopes on, or just for the wider field of view. When trying to view near the zenith, use a reclining lawn lounger: you can lie back and support your arms on the chair, giving a steadier view. You also will not get a crick in your neck.

You might also use a plastic pad to lie on.

10.1. How Do I Hold Binoculars?

This section was written by Jay Freeman.

If you don‘t have a tripod (and tripods are sometimes a little clumsy, and are often difficult to use when the binocular is pointing near the zenith), it is important to know how to hold a binocular correctly to achieve maximum steadiness.

The way most people tend to hold a binocular is with one hand on each side of the middle of the body-roughly where the prisms are in a conventional 7x50, say, so that the left hand is directly to the left of the center of gravity of the instrument and the right hand is directly opposite it, to the right of the center of gravity. For most people, there is a better position. Imagine that you are holding the binocular to your eyes, with your hands positioned as just described. Now, slide your hands along the body of the instrument,toward your face, until only your pinky and ring fingers are curled around the back end of the binocular body. In this position, the binocular feels a little nose-heavy, because you are supporting it behind its center of gravity.

Now curl each thumb up as if you were making a fist, and flex your hands so that the second bone in from the tip of your thumbs are pressed up against your cheekbones (counting the bone in the part of your thumb where the thumbnail is, as the first bone). This makes a quite solid structural connection between the body of the binocular, through your hands and thumbs, to your face, and markedly improves how steadily you can hold the instrument. Similarly, curl the first and middle fingers of each hand around the corresponding binocular eyepiece, to provide a little more structural connection (and perhaps also some protection from stray light). In this position, your hands are not far from where they would be if you brought them to your face to block out stray reflections while peering through a store window at night. For most people, this position leads to markedly steadier viewing, but if the binocular is especially long and heavy (say, a 10x70 or an 11x80), the out-of-balance position can be quite tiring. In that case, move **one** hand out to the objective end of its side of the binocular, so that you are supporting the instrument on opposite sides of its center of gravity, but with some structural connection between it and your face; namely, the other hand. When the hand way out there gets tired-just switch hands.

For each person, there is a limit to how heavy and / or how powerful a binocular can be, before there is no way for that person to hold it steady enough. I am an averaged-sized adult male in reasonable physical condition, and I find I can hold a 10x70 (Orion‘s) steadily enough to use indefinitely on astronomical objects. But I have an old Celestron 11x80, that doesn‘t look much bigger or heavier than the 10x70,that I can only use for a few minutes before my arms get tired. As a 12-year old I am sure I could have used a 7x50 indefinitely with no problem, but at a younger age I might have had difficulty using one continuously. Your experience may vary with your strength, size and condition. Try before you buy, if at all possible.

10.2. What Are Some Eye Relief Figures?

If you need to wear eyeglasses while looking through binoculars (presumably you have astigmatism, but if you require many diopters of correction you might need to as well) you need reasonably good eye relief. Dana Bunner contributes the following table:

Model	Advertised ER	Measured ER
Bausch & Lomb 7x26 Custom	16	15
Celestron 10x50 Pro	15	10
Celestron 7x42 Ultima	23	19
Celestron 7x50 Ultima	20	16
Celestron 10x50 Ultima	19	17
Celestron 8x56 Ultima	21	11
Fujinon 8x40 BFL	19	17
Fujinon 7x50 FMT-SX	23	20
Fujinon 10x70 FMT-SX	19	17
Minolta 7x50 Standard	18	16
Minolta 10x50 Standard	?	9 (FYI)
Minolta 10x50 XL	18	16
Nikon 8x30E Criterion	13	13
Nikon 7x50 Windjammer	16	16
Optolyth 10x40 Touring	13	12
Pentax 8x24 UCF	13	8
Pentax 7x35 PCF	14	9
Pentax 7x50 PCF	20	10
Swift 8x25 Micron	13	11
Zeiss 7x42 B/GA T Dialyt	19	18
Zeiss 20x60S	?	14 (FYI)

11. What Books and Star Charts Are Recommended?

If you don‘t know the constellations, you might want a book that will help you learn them. A „fun“ book for those just learning the stars is ***The Stars, A New Way of Seeing Them*** by H. Rey, which presents a non-orthodox way of drawing the constellations so they are easier to visualize. You will probably want a beginner‘s guide, such as the book by Sherrod mentioned above. Sky Publishing has some introductory materials which would probably be as useful, which you get for free when you subscribe to Sky and Telescope.

Petersen‘s Field Guide to the Stars and Planets comes highly recommended. It is very inexpensive ($13), small and handy to use at the telescope. It has a good discussion about stars, planets, nebulae, and galaxies; and has a very complete albeit small-scale star chart, along with a the usual tables. It hasm long lists of deep-sky objects for each area of the sky. You will need a bigger star chart than is included in Petersen‘s. Try ***Sky Atlas 2000.0***, by Wil Tirion. The field edition, which has white stars on a black field, is probably more useful than the desk guide. It is also printed on heavier paper, so is more resistant to dew and the rigors of the night. For beginners, buying ***Uranometria 2000.0*** is probably a mistake. Yes, it is the „best“ star chart, but the scale is impossibly small- when the Orion constellation takes up four separate pages it is really hard to use for beginners.

Burnham‘s Celestial Handbook ($36). This three volume set is billed as ***„An Observer‘s Guide to the Universe Beyond the Solar System“*** rather all-encompassing claim, which it manages to live up too. Information on every item of interest you can think of: galaxies, double stars (optical and binary),variable stars, nebulae, etc. More information than you could use in a lifetime. I consider this a necessity. Sky and Telescope‘s ***100 Best Deep Sky Objects***. About $5, which is kind of expensive for a list, but it sure makes it easier to figure out what to look at when you are just beginning. The items are sorted by Right Ascension, which makes it real easy to figure out which ones are currently up.

All the materials listed are available from:

Sky Publishing Corporation
P.O. Box 9111
Belmont, MA 02178-9918 USA

Their catalog is free.

11.1. What About Computer Programs?

There are to many types of computer programs that I can NOT review, as they do not run on my machine. I think there should be a FAQ just for all the computer programs.

12. About this FAQ

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