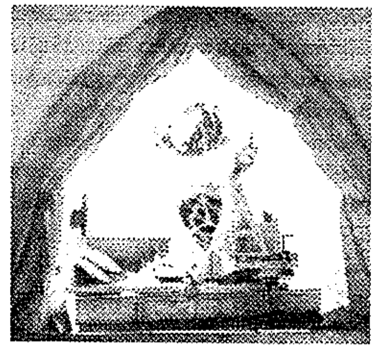
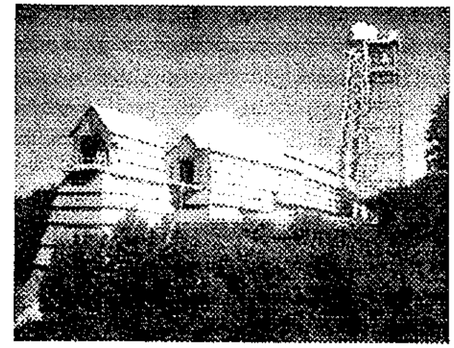
# the focal point

Monthly Notices of the Atlanta Astronomy Club, Inc.

Vol. VII No. 1 June, 1994





**Why is this telescope famous?**

**See page 13**

## IN THIS ISSUE

- *The Editors of Astronomy Magazine Tell How to Pick a First Telescope.*
- *How Does Hubble Compare to Earth-Based Telescopes? NASA Reveals All.*
- *Jack Kramer Tells How to Make Your Own Solar Filter.*

**NEXT MEETING – JUNE 17**

**TIM PUCKETT DESCRIBES HIS NEW OBSERVATORY**

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the focal point

Monthly Notices of the Atlanta Astronomy Club, Inc.

FROM:
**Leonard B. Abbey, Editor**
**1002 Citadel Drive**
**Atlanta, Georgia 30324**

The Atlanta Astronomy Club Inc., the South's largest and oldest astronomical society, meets at 8:00 p.m. on the third Friday of each month at Agnes Scott College's Bradley Observatory. Occasional meetings are held at other locations (check the hot line for details). Membership is open to all. Annual dues are $20 ($10 for students). Discounted subscriptions to *Astronomy* ($18), and *Sky & Telescope* ($20) magazines are available. Send dues to **Alex Langoussis, Treasurer, 2936 Lowe Way, Marietta, Georgia 30066**

**Hot Line** Timely information on the night sky and astronomy in the Atlanta area is available on a twenty-four hour basis on the Atlanta Astronomy Club hot line 621-2661

**BBS** The Atlanta Astronomy Club operates a computer bulletin board at 455-3089. The BBS, which is free and open to the public, provides contact with both amateur

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# BUYING YOUR FIRST TELESCOPE

## A Beginner's Top 30 Questions

### by the Editors of Astronomy Magazine

Buying your first telescope can seem like a complicated affair. There are many models to choose from and many technical terms to contend with. To help you make the right choice, here are answers to 30 of the most-asked questions we get from prospective telescope buyers. We trust you'll find answers to your questions among them.

> ...refractors usually provide slightly sharper images than reflectors of similar aperture...

If not, please call us at *Astronomy* magazine ((414) 796-8776 Monday to Friday, 8:30 a.m. to 5:00 p.m. Central Time), or see your local telescope dealer.

***1. How much does it magnify?***

Beware of any telescope advertised as "500X" or "high-power." Some manufacturers make it sound as if the more magnification a telescope offers, the better it is. This is not true. Contrary to the claims of department-store catalogs, magnification is not important.

Any telescope can be made to magnify any amount. However, the highest power that will still give you a clear view is about 50X per inch of aperture, making the upper limit for a 3-inch telescope 150X, and for a 4-inch telescope 200X. Beyond this limit, the image will be faint, fuzzy, and disappointing.

***2. How, do I select the best telescope?***

The key characteristic of a telescope is its aperture – the diameter of the main lens or mirror. The larger the aperture, the more light the telescope gathers and focuses into the image. This in turn makes for a brighter, and usually clearer, image. Brighter images make it easier to see faint objects like nebulae and galaxies.

***3. Which are better – refractors or reflectors?***

A refractor uses a lens mounted at the front of the telescope to gather and focus light. A reflector uses a concave or bowl-shaped mirror mounted at the back of the telescope. Both work well; each has its advantages. Reflectors generally offer more aperture for the money. (A 4-inch reflector costs $400 to $500; 4-inch refractors start at $1,000 or more.)

However, refractors usually provide slightly sharper images than reflectors of similar aperture. Amateur astronomers who like to view fine details on planets often prefer refractors; those who like to look at faint deep-sky objects use reflectors. For most first-time buyers on a budget, either an 80-mm or 90-mm refractor or a 4.5-inch reflector is a good choice. Either costs $400 to $600 and they have comparable performance.

***4. What are Schmidt-Cassegrain telescopes?***

A third type of telescope, called a catadioptric, uses a combination of mirrors and a refractive corrector lens at the front. The most popular of these hybrid models is the 8-inch Schmidt-Cassegrain (prices start at $1,200). It folds a long focal length into a compact tube, making this type of telescope very portable and convenient to use for its aperture. It is also a good general





## WHAT'S UP

| Date | SUN Rise | SUN Azi | SUN Set | SUN Azi | MOON Rise | MOON Azi | MOON Set | MOON Azi | Age |
|---|---|---|---|---|---|---|---|---|---|
| 6/15/94 | 6:26 | 60.9 | 20:50 | 299.1 | 12:33 | 86.2 | 0:31 | 276.6 | 6.7 |
| 6/16/94 | 6:26 | 60.8 | 20:50 | 299.1 | 13:36 | 92.3 | 1:06 | 270.7 | 7.7 |
| 6/17/94 | 6:26 | 60.8 | 20:50 | 299.1 | 14:40 | 98.3 | 1:42 | 264.8 | 8.8 |
| 6/18/94 | 6:26 | 60.7 | 20:51 | 299.2 | 15:47 | 104.1 | 2:20 | 258.9 | 9.9 |
| 6/19/94 | 6:27 | 60.7 | 20:51 | 299.2 | 16:55 | 109.0 | 3:01 | 253.5 | 11.0 |
| 6/20/94 | 6:27 | 60.7 | 20:51 | 299.2 | 18:03 | 112.8 | 3:47 | 249.2 | 12.2 |
| 6/21/94 | 6:27 | 60.7 | 20:51 | 299.2 | 19:09 | 114.9 | 4:39 | 246.1 | 13.3 |
| 6/22/94 | 6:27 | 60.7 | 20:52 | 299.2 | 20:11 | 115.2 | 5:37 | 244.7 | 14.4 |
| 6/23/94 | 6:27 | 60.7 | 20:52 | 299.2 | 21:07 | 113.6 | 6:39 | 245.3 | 15.5 |
| 6/24/94 | 6:28 | 60.7 | 20:52 | 299.2 | 21:56 | 110.5 | 7:44 | 247.6 | 16.6 |
| 6/25/94 | 6:28 | 60.8 | 20:52 | 299.1 | 22:39 | 106.1 | 8:49 | 251.3 | 17.7 |
| 6/26/94 | 6:28 | 60.8 | 20:52 | 299.1 | 23:16 | 101.0 | 9:53 | 256.1 | 18.7 |
| 6/27/94 | 6:29 | 60.8 | 20:52 | 299.0 | 23:50 | 95.7 | 10:54 | 261.4 | 19.7 |
| 6/28/94 | 6:29 | 60.9 | 20:52 | 299.0 | ----- | ----- | 11:52 | 267.0 | 20.6 |
| 6/29/94 | 6:29 | 61.0 | 20:52 | 298.9 | 0:22 | 90.2 | 12:48 | 272.5 | 21.6 |
| 6/30/94 | 6:30 | 61.0 | 20:52 | 298.8 | 0:53 | 84.9 | 13:43 | 277.8 | 22.5 |
| 7/1/94 | 6:30 | 61.1 | 20:52 | 298.7 | 1:24 | 79.9 | 14:38 | 282.6 | 23.4 |
| 7/2/94 | 6:31 | 61.2 | 20:52 | 298.6 | 1:57 | 75.4 | 15:32 | 286.9 | 24.2 |
| 7/3/94 | 6:31 | 61.3 | 20:52 | 298.5 | 2:31 | 71.4 | 16:26 | 290.5 | 25.1 |
| 7/4/94 | 6:32 | 61.4 | 20:52 | 298.4 | 3:09 | 68.2 | 17:19 | 293.2 | 26.0 |
| 7/5/94 | 6:32 | 61.5 | 20:52 | 298.3 | 3:51 | 66.0 | 18:12 | 294.8 | 26.9 |
| 7/6/94 | 6:32 | 61.6 | 20:52 | 298.2 | 4:37 | 64.9 | 19:03 | 295.1 | 27.9 |
| 7/7/94 | 6:33 | 61.8 | 20:51 | 298.0 | 5:28 | 65.1 | 19:51 | 294.2 | 28.8 |
| 7/8/94 | 6:34 | 61.9 | 20:51 | 297.9 | 6:23 | 66.7 | 20:36 | 291.9 | 0.3 |
| 7/9/94 | 6:34 | 62.1 | 20:51 | 297.7 | 7:22 | 69.6 | 21:18 | 288.3 | 1.3 |
| 7/10/94 | 6:35 | 62.2 | 20:51 | 297.6 | 8:22 | 73.6 | 21:57 | 283.8 | 2.3 |
| 7/11/94 | 6:35 | 62.4 | 20:50 | 297.4 | 9:24 | 78.6 | 22:34 | 278.5 | 3.3 |
| 7/12/94 | 6:36 | 62.6 | 20:50 | 297.2 | 10:26 | 84.3 | 23:09 | 272.6 | 4.3 |
| 7/13/94 | 6:36 | 62.7 | 20:50 | 297.1 | 11:29 | 90.3 | 23:45 | 266.8 | 5.4 |
| 7/14/94 | 6:37 | 62.9 | 20:49 | 296.9 | 12:33 | 96.3 | ----- | ----- | 6.4 |
| 7/15/94 | 6:38 | 63.1 | 20:49 | 296.7 | 13:38 | 102.1 | 0:22 | 260.8 | 7.5 |

### OFFICERS AND OTHER DIGNITARIES

| | | |
|---|---|---|
| President: | Steve Gilbreath | 409-1915 |
| First Vice-President: (Program) | Jerry Armstrong | 942-4249 |
| Second Vice-President: (Observing) | Eric Shelton | 664-2837 |
| Recording Secretary: | Terry McHann | 441-9097 |
| Corresponding Secretary: | Leonard Abbey | 634-1222 |
| Treasurer: | Alex Langoussis | 429-8384 |
| BBS: | Doug Chesser | 457-5743 |
| Edibles: | Terry McHann | 441-9097 |
| Facilities | Leonard Abbey | 634-1222 |
| Light Pollution: | Tom Buchanan | 587-0774 |

## THE JUNE MEETING

Our next meeting will be held at **8:00 p.m.** on **June 17**, at **Bradley Observatory**. The speaker will be **Tim Puckett, who will describe the design and construction of his new observatory**. When completed, the observatory will house a 24" Ritchey-Chretien reflector. It will be the third largest telescope in Georgia.

You know the phrase. "If you want something done right, do it yourself." If you get to this meeting, you'll see how Tim has decided to "do" his own observatory exactly the way he wants it.

Armed with color slides and lots of hands-on experience, Tim will walk us through the building, and take a look at the scope and controls. He will also show some of the celestial objects he has already photographed.

As one-half of the team that discovered the supernova S1994I in the Whirlpool Galaxy (M51) last April, Tim is very adept at his craft and is looking forward to sharing his enjoyment with us.

## OBSERVATORY REPORT

**by Alex Langoussis**

In September, we opened up the Agnes Scott telescope at meetings again, thanks to Lenny Abbey and Alberto Sadun. At Villa Rica, we put the 8" Maksutov back in operation, giving us 3 fine telescopes.

Due to the fine efforts of Ken Poshedly, the First Annual Peach State Star Gaze was a success, and a heck of a lot of fun! Of course, we were all happy for Tim and Jerry. Their years of hard work finally paid off big-time, with their M51 supernova discovery.

I think one of our greatest achievements this year was our reaching out and electronically connecting to the world astronomical community. Lenny took over the Astro list-server last fall, providing a link for astronomers around the world. Club members were permitted access to the circulars from the IAU, enabling us to know of discoveries almost immediately. Doug Chesser has improved the Atlanta Astronomy Club BBS month by month, giving us internet messaging. We now can share knowledge and experiences with astronomers worldwide, quickly, and for free!

The club's most pressing task this year is to find an additional, darker observing site. Development is skyrocketing in the area of our current observatory. We need to act quickly. Members who know of specific possible sites, please let me or one of the board members know. We'll check it out. Keep the pressure on us! This year's board should be judged on whether we succeed or fail in finding a dark site.

I've had a lot of fun as observatory chairman this year. However, I cannot afford to gain another 17 lbs. at the Villa Rica Waffle House! I hope you'll all give Eric Shelton your help and support.

This coming weekend, June 10-11, should be great for observing (weather permitting, of course!). Come out and join us as the stars of summer take the celestial stage!





purpose telescope suitable for observing all classes of celestial targets.

The two main manufacturers of this type of telescope are Celestron International and Meade Instruments Corporation. These two companies are very competitive and offer a similar range of Schmidt-Cassegrains, from basic no-frills units to feature-laden computer-controlled models. Which company makes better telescopes? Over the years we have never found a consistent winner between the two, either in optical or mechanical quality.

***5. What are apochromatic refractors?***

One of the principal problems with conventional refractors over 80-mm aperture is spurious color around bright objects caused by the inability of the lens to bring all colors to the same point of focus. To greatly reduce this "chromatic aberration," manufacturers have introduced refractors that use 3-element lens systems or special fluorite or "ED" lenses. Called apochromatics, these high-end refractors are among the finest optical systems you can buy and have become popular with telescope aficionados. Models are available from Astro-Physics, Celestron, Meade, Takahashi, and Tele Vue. However, a 4-inch "apo" refractor can cost $2,500 to $5,000; more than many people wish to spend on a first telescope.

***6. How much more will I see with a bigger telescope?***

Bigger telescopes can show fainter objects and resolve finer details in bright objects. For example, a 2.4-inch (60-mm) refractor will easily show the cloud belts of Jupiter, a 4-inch will show structure within the cloud belts, and an 8-inch will resolve even smaller details. A 4-inch will show globular star clusters as fuzzy-edged spheres of light, a 6-inch will resolve many globulars into myriad faint stars, and a 12-inch will provide views of these clusters that surpass any photograph. While a 4-inch will reveal a spiral galaxy as a round glow, an 8-inch will begin to reveal the galaxy's spiral arms.

***7. Will I be happy with a smaller scope?***

The fact that bigger telescopes usually show more details and fainter objects leads many people to believe small scopes aren't worth buying. But even an 80-mm refractor can show you enough of the universe to keep you entertained for years. For many people it's all the telescope they ever need.

We warn people against buying a telescope that is too large – yes, there is such a thing. A big telescope, though exciting at first, can quickly become a burden to carry out to the yard or car and to set up. The best telescope is not the biggest, or even the one with the best optics, but the one that you will use most often. Portability and convenience are factors we urge you to consider when selecting a telescope that you'll have fun using.

***8. I live in the city (country) where the skies are terrible (great). What type of telescope is best for me?***

A large-aperture telescope can be useful at any site, but faint deep-sky objects (the kind big scopes are well-suited for) won't show up well under urban skies, no matter what size the scope. City observers often spend more time looking at the Moon and planets, for which a 3- to 8-inch telescope is sufficient. Telescopes in that size range are also very portable, important for city observers who need to transport their scopes to better skies. For most buyers, we feel that a 5-inch refractor, a 6-inch equatorial reflector, an 8-inch Schmidt-Cassegrain, or a 10-inch Dobsonian reflector (see question 16) are the largest telescopes of their types that are conveniently portable. Only if you live under dark skies, or really don't mind lugging a big, heavy scope around, should you consider anything larger for a first telescope.

***9. What does focal length mean? and f/ratio?***

The focal length of a telescope is the length of the light path from the main lens or mirror to the eyepiece. In most refractors or reflectors, the focal length is roughly the length of the tube. In telescopes such as Schmidt-Cassegrains in which the light path is bounced back and forth inside the tube several times, the length of the tube is much shorter than the focal length. Focal lengths of telescopes, as with camera lenses, are usually measured in millimeters.

The f/ratio of a telescope is the focal length divided by the aperture. For example, a 100-mm-aperture telescope with a 900-mm focal length is an f/9 telescope. A 200-mm telescope (an 8-inch) with a focal length of 1,800-mm is also an f/9.

### *10. What focal length is best?*

The focal length of the telescope is not a critical specification. Shorter focal lengths (400- to 700-mm) will give lower powers and wider fields of view with any given eyepiece than will telescopes with moderate (800- to 1,200-mm) or long focal lengths (1,300- to 3,000-mm). For this reason, short focal lengths are often preferred for low-power viewing of deep-sky targets and Milky Way starfields. On the other hand, a long-focal-length scope will give a higher power with any given eyepiece. Since the planets require higher powers (100X to 200X), planetary fans often prefer long-focal-length scopes. But with the use of the appropriate eyepieces, most telescopes can be used at both low and high powers.

### *11. Is a faster telescope better?*

Sometimes manufacturers give the impression that a "faster" telescope (one with an f/ratio of f/4 to f/6) is better than a "slow" telescope (f/7 to f/16). After all, in many situations faster is better. But in this case it isn't. The term "faster" comes from photography where an f/4 lens will record an image with a faster exposure time than an f/16 lens. And for those intending to take long-exposure photos through a telescope, faster can be better.

But when looking through a telescope, a faster telescope is not any brighter than a slower scope. For example, as long as both are operating at the same power, the image in an 8-inch f/6 telescope will appear as bright as the image in an 8-inch f/10 scope. The difference is that with the same eyepiece the f/6 telescope will give a lower power and a wider field of view than will the f/10, making faster scopes preferred for deep-sky observing where wide fields are desirable.

### *12. What are the eyepieces for?*

Eyepieces allow you to change magnification. To determine the magnification an eyepiece gives, divide the focal length of the telescope by the focal length of the eyepiece. For example a 25-mm focal length eyepiece used on a 2,000-mm focal length scope (such as an 8-inch f/10 scope) will give 2000/25 = 80X. The same eyepiece used on a 1,600-mm scope (such as an 8-inch f/6) will give 64X.

### *13. What is the small finderscope for?*

Finderscopes are essential accessories. They provide a low power (5X to 8X) and a wide field (3° to 5°) and allow you to aim the telescope easily and center it on bright planets and stars. Without a finderscope locating even the Moon can be difficult.

### *14. Why are images in telescopes upside-down?*

All astronomical telescopes present images that are either upside-down or flipped left-to-right as in a mirror. To flip the image right-side up would require extra lenses in the light path that would dim the view of already faint astronomical objects or add imperfections like flares and ghost images.

### *15. Which is better - an altazimuth or equatorial mount?*

Alt-azimuth mounts use simple up-down (altitude) and side-to-side (azimuth) motions to aim the telescope. The best of these mounts are equipped with slow-motion controls to allow you to make fine adjustments to the position of the scope. However, alt-az mounts cannot auto-





# AAC ACTIVITIES

## Culinary "Observing" the Order Of the Night on May 20

If it's true that a club, like an army, travels on its stomach, the Atlanta Astronomy Club is well ahead of everyone else.

It was a truly overflow crowd of more than 50 members and guests who attended the Club's banquet evening get-together at the Tucker Steak-and-Ale restaurant on Friday, May 20.

Besides dinner, the items for the evening included:

- Formal announcement by Lenny Abbey that the Club will hold some future meetings at Emory University's White Hall.
- Election by acclamation of the slate of candidates submitted by the nominating committee (see the official listing elsewhere in this newsletter).
- Observing reports from various persons about the May 10 annular eclipse of the Sun. As it turns out, we had the eastern half of the country covered with member reports of local observing here in Georgia, and other reports about observing in other states including Wascon, Ohio, where "total" annularity was the longest of any point in the eclipse path.

A hearty thanks to Hal Crawford for his hard work in chairing the nominating committee and dinner arrangements as well.

And congratulations to our officers. May they serve well and often!

## The Editor Says....

This year our bylaws have changed, and one of those changes affects the *Focal Point*. In order to keep our volume numbers synchronized with the Club's year, volume 6 (last year) will have only nine issues. With this issue, we begin volume seven, and each volume will henceforth have the customary twelve issues.

glue might outgas, thus damaging the aluminum coating. I found that once the mylar hits the double-faced tape, it really sticks fast. As a result, one of my filter layers ended up with a bad wrinkle. From an aesthetic standpoint, this looks crummy, but since I'd probably destroy the piece of material were it to be removed, I decided to leave it as is. In actual use, I couldn't detect any adverse effect on the image attributable to the wrinkled filter. The solar image kept going in and out of focus, but that appeared to be more the effect of atmospheric turbulence (the winter Sun is very low in the sky). Also, it takes awhile for the optics to reach equilibrium temperature in the cold air. Later in the year when the Sun is higher in the sky I'll revisit this issue again.

The instructions stated that for maximum contrast, all stray light should be eliminated in the body of the telescope. The background was very bright in my strut-tube scope, so I used a shroud of black fabric to cover the body of the telescope. While this didn't eliminate all the stray light, it did improve the contrast significantly. Since the shroud was open in spots, I suspect it induced additional air currents, which might relate to the image instability mentioned above. I found that shielding your face from the sunlight which comes from the side is even more important. This "external stray light makes it very difficult to see the solar image in the eyepiece.

## Observing

The filter opened up an interesting new perspective on our Sun. The delicate details of sunspots stand out much better than when projected. Since the solar rotation period is about one month, it's possible to track the progress and change in sunspots for several days as they move across the photosphere, the part of the Sun where we see most of the details. An interesting exercise is to measure the size of solar features by comparing them with the Sun's diameter of 865,000 miles. An eyepiece with a measuring reticle would be a big help here.

The chromosphere rises to about 6000 miles above the photosphere; it is here that the fraunhofer absorption lines in the solar spectrum are produced. Primarily through spectrographic analysis, we know the Sun is composed of 75% hydrogen, 24% helium, with the remaining 1% comprised of some 70 other elements. The corona is the tenuous outermost layer of the Sun, which is seen only during total solar eclipses. The core is the hottest part; here the temperature is estimated to be about 27,000,000°, with a gradual cooling in subsequent zones, down to 10,000° in the photosphere. Sunspots are actually quite bright, but since they're cooler than the surrounding areas, they just appear to be darker. Faculae are the small bright (hot) streaks that are visible in the photosphere.

A few more details are worth noting. Because the Sun is 93 million miles from Earth (one "astronomical unit"), it takes its image 8 minutes and 20 seconds to reach us. And it takes the Sun (i.e.: the Solar System) 225 million years to make one revolution around the Milky Way.

Large sunspot groups can signal that there may be some auroral activity within a day or two. We're currently in a quiet part of the eleven-year solar cycle, but every now and then there's a nice sunspot group. If you have a shortwave radio, you can listen to station WWV, which broadcasts information on the solar conditions at 18 minutes after each hour. In any event, you do not have to put away your telescope after the Sun rises. This is "daytime astronomy" at its best!





matically follow the stars as they appear to arc across the sky from east to west.

An equatorial mount is more complex. It can follow the stars across the sky with a single motion around one axis. If the telescope is equipped with a motor, the telescope will automatically track the stars. This is a nice feature because at magnifications of 100X or more, the apparent motion of the sky will cause objects to drift out of the field of view in less than a minute. Having to recenter the image constantly can be distracting, inconvenient, and can introduce vibration that shakes the image.

### *16. What about Dobsonian telescopes?*

Dobsonian is a Newtonian reflector. Its unique feature is a simple wooden alt-azimuth mount that rides on Teflon pads. The philosophy of the popularizer of this type of telescope, John Dobson, was to keep the scope easy-to-build and low-cost. The design also lends itself to relatively large apertures. Dobsonians cannot track the stars automatically, but their motions are very smooth - it's easy to nudge the scope every so often to recenter the object. As of 1992, only one manufacturer was selling low-cost Dobsonian telescopes – Coulter Optical Company. Their models offer big aperture for very little money (for example, a 10-inch reflector for under $400). People often wonder if there's a catch. There are a few: Coulter scopes are in such demand that you may have to wait several months to a year for delivery. You must order directly from the factory and pay shipping costs from their plant in California (which may add up to $100 to the cost). You will also need to add a finderscope. The fit and finish of the scopes is nothing fancy – the mounts are painted chipboard, the tubes cardboard. Our opinion? For the money the quality of construction and optics can't be beat. The 8- and 10-inch Coulter models make good starter scopes. The 13- and 17-inch models are best for die-hard deep-sky observers.

### *17. I've heard you can make your own telescope.*

The Dobsonian design lends itself to do-it-yourselfers. Plywood for the mount and a cardboard tube like those used for concrete forms are the main ingredients. Few people make their own mirrors these days. It can be done, but ready-made mirrors from suppliers such as Coulter, Meade, Parks and other suppliers don't cost much more than mirror- making kits. You'll also need a focuser and cells to hold the main mirror and the small secondary mirror. For more information about telescope making see the book *Build Your Own Telescope* by Richard Berry, available from Kalmbach Publishing.

### *18. Which accessories do I need?*

Some telescopes come with only one eyepiece. Additional eyepieces for higher and lower powers are the first accessories most first-telescope owners need to buy. An accessory called a Barlow lens can double or triple the power of each eyepiece, but the best Barlows (the only ones worth buying, trust us!) cost $80 to $100.

Colored filters can enhance views of the planets slightly, but the difference is subtle. They are not essential. Nebula or light pollution filters can improve views of some deep-sky objects like emission and planetary nebulae, but they do little to improve star clusters and galaxies. Contrary to what many beginning backyard astronomers believe, these filters are not a cure-all for light-polluted skies.

Computerized digital readouts to aid in finding objects have become popular telescope accessories in recent years. They work ell but are luxury options for those that can afford their $500 to $1,000 price tags.

### *19. Are enhanced coatings worth the extra cost?*

Some telescopes are offered with special lens or mirror coatings as optional extras (Celestron's Starbright™ and Meade's MCOG, for example). These increase the light transmission, yielding images up to 15 percent brighter. They are definitely worth the extra expense.

***20. Can I use setting circles to find things?***

Many equatorial mounts are equipped with graduated dials called setting circles. Theoretically, these allow you to find objects by moving the telescope so that the circles' readings match the celestial coordinates (called Right Ascension and Declination) of the object you're looking for. However, in our experience we have rarely seen a novice amateur astronomer (nor many experienced ones!) who have been able to make effective use of setting circles. Poor alignment of the telescope mount, improperly calibrated circles, and imprecise circle scales usually combine to make circle readings inaccurate. The best method to find celestial targets is to hop from star to star using a good star chart as your guide. Plan on buying such a star chart as an essential accessory.

***21. Can I take pictures with this scope?***

Anything you see through a telescope can be photographed, but most objects require exposures of several seconds to an hour or more. Keeping the object perfectly positioned on the film during that time requires a solid equatorial mount and a motor drive. These are essential features if you intend to do astrophotography.

***22. Can I use a spotting scope for astronomy?***

Some spotting scopes (such as those sold for birding) have only a fixed-power eyepiece or a variable zoom eyepiece. These models are unsuitable for astronomy. Other models use interchangeable eyepieces but must be placed on a solid camera tripod. Because they lack fine slow-motion controls, camera tripods are difficult to aim precisely, a problem at high power.

***23. But I also want to use my telescope for nature observing.***

If your interests mix astronomical and terrestrial viewing, we suggest an 80-mm or 4-inch refractor, or a small 4-inch Schmidt-Cassegrain. Don't buy a Newtonian reflector – the position of the eyepiece makes a Newtonian awkward for use as a spotting scope.

***24. How much should I have to spend?***

We feel that $400 to $500 is the minimum for a quality starter scope such as an 80-mm refractor or 4.5-inch reflector. The next step up is to a 6-inch equatorially-mounted reflector (such as the models from Celestron, Meade, Parks Optical, or Pirate Instruments). These sell for $600 to $900.

The next jump up many first-time buyers consider is to an 8-inch Schmidt-Cassegrain ($1,200 to $2,500). No-frills Dobsonian reflectors defy these price/aperture categories by offering much more aperture for the money (see question 16).

***25. What does "1/20th-wave optics" mean?***

The deviation of an optical surface (lens or mirror) from the ideal shape is often stated as a fraction of a wavelength of light. The smaller the fraction, the better the optics and the sharper the image. However, to be meaningful for a complete telescope this deviation figure should be provided for the final wavefront reaching the eye, not just for individual lenses or mirrors. When measured in this manner, a telescope with a total error on the final wavefront of 1/4 wave is very good, 1/8 or 1/10 wave is excellent, and 1/20 wave is outstanding but seldom achieved. Manufacturers have no agreed-upon standard for measuring these values - one company's 1/20 wave may be the same as another company's 1/10 wave.

***26. What does "diffraction limited" mean?***

This is another freely used term in telescope advertising. It means that the optics





achieve sufficient darkening. Moreover, the cheap stuff is easy to scratch. For the sake of protecting your vision, it's important that there be no pinholes or thin spots through which the blinding solar light can enter your eyepiece. The optical-quality type has a uniform coating of aluminum; when mounted properly, this coating is protected between two layers of mylar.

The glass filters give a yellow-orange solar image, while mylar gives a light blue image. Although both filters are equally safe, the coated mylar removes more of the infra-red radiation, thus causing the blue cast. A #15 yellow or #21 amber filter added on the eyepiece gives a more natural rendering. I chose the aluminized mylar because it offered the greatest amount of material for the money. One advantage of glass is that it induces slightly less image distortion, though I haven't noted any problems that are obviously attributable to the mylar.

The material comes as two pieces of mylar. While I selected the 6"x6" size from the catalog, each piece as delivered was actually over ten inches square. For adequate darkening, two pieces must be used together with the aluminized (shiny) sides facing each other; this protects the aluminized layers from abrasion and from atmospheric contaminants. The bonus of the extra material allows for any mistakes that might ruin a piece of mylar and/or provide leftovers for a camera or spotting scope filter.

### Mounting the Filter

Both the glass and mylar filters come with cells or they can be purchased separately for custom mounting. The Sun's image is so bright that on larger telescopes *you don't need to use full aperture*. Many users make an off-axis diaphragm, sometimes referred to as an "aperture mask", in which the hole (diaphragm) is covered by the mylar or glass filter.

The illustration shows the filter mounted on an off-axis diaphragm for use with a reflecting telescope, either a Newtonian or Schmidt-Cassegrain. An off-axis diaphragm has the added benefit of sharpening the image by bypassing the secondary mirror. On a refractor, you can also use a diaphragm, except that the hole would be centered on the primary lens, since there's no secondary obstruction. Just make sure the mask is securely fastened to the scope so it can't be accidentally knocked off while observing!

The cost comparison below shows the alternatives (exclusive of shipping or tax) for a diaphragm on a 10" scope.

| | | |
|---|---|---|
| Mylar sheet | 6" X 6" | $39 |
| Mylar in cell | 4" | 79 |
| Glass unmounted normal | 4" | 49 |
| extra durable | 4" | 66 |
| photographic | 4" | 79 |
| Glass in cell normal | 4" | 59 |
| extra durable | 4" | 76 |
| photographic | 4" | 99 |

For my 10" Newtonian, I made an aperture mask with a diaphragm slightly smaller than four inches. I purchased the mylar filter material from Roger W. Tuthill, Inc. The prices shown for the glass filters are for the Thousand Oaks brand. Full aperture filters would obviously cost much more.

The mylar is reasonably tough, but very flimsy, which means a pair of *sharp* scissors is needed to cut it. The instructions caution against stretching the mylar to remove wrinkles. Specifically, we are warned: "Do *not* try to stretch it flat, as the molecules in the material become disoriented and the result is a less superior image as far as contrast is concerned." It's hard not to give into the temptation to make the filter lie perfectly smooth and taut! The instructions stipulate that the filter must be mounted using double-faced tape, since

# Solar Filters

## by Jack Kramer, Libertyville, Illinois

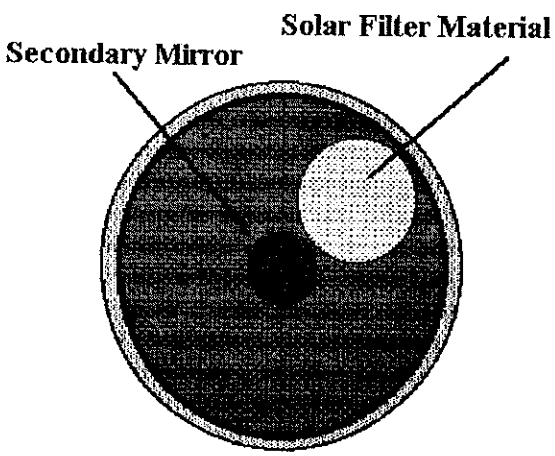
With the annular eclipse coming, there's a renewed interest in observing the Sun. This prompts some consideration of the best way to view details on our nearest star.

In the past, I used the projection method – using the eyepiece to project the Sun's image onto a white screen. This has worked very well for group observing, since several people can view the image simultaneously. However, my 10" scope gathers so much light that the eyepiece heats up to the point that it becomes too hot to touch. This can cause irreparable harm if the adhesive that binds the lenses is caused to melt. The effects would be seen as bubbles and/or discoloration between the lens elements of the eyepiece. To avoid ruining good optics, I used a cheap eyepiece that I bought for $5 at the American Science Center several years ago. In addition, projection doesn't show as detailed an image as can be seen with direct viewing.

With this in mind, I decided to acquire a solar filter for direct viewing, which would also permit the use of better eyepieces. This filter is *not* the type that was once sold for mounting on eyepieces. That type of filter is extremely dangerous because it heats up just like the eyepiece. If it were to shatter from the heat, the observer could be blinded. The correct type of filter covers the skyward end of the telescope so less than 1% of the Sun's light enters the optical system.

### Filter Material

There are two standard types of filter material. The more durable, and more expensive, is a glass filter that has been coated with special materials to reduce the Sun's brightness. These are available in three variations: normal, extra durable, and lower density for astrophotography. The alternative is aluminized mylar, but not the cheap type that you normally buy off rolls at places like the Science Center. If you've ever looked at the roll-type material, you've noted that the coating is fairly thin and uneven. You have to use several layers to




The configuration of a solar filter.





are so good they are limited only by the wave nature of light and not by any flaws in the surface accuracy of the lenses or mirrors. Specifically, it means the final wavefront error is better than 1/4 wave, a figure known as Rayleigh's Criterion. Again, few manufacturers have the technical equipment to quantitatively support this claim. Most test telescope quality by ensuring units form good star images. Although this is a very sensitive test that will detect small flaws in the optics, it cannot guarantee a numerical specification like 1/4 wave.

***27. Where can I buy a good telescope?***

We suggest shopping at a local telescope dealer if there is one near you (check the Yellow Pages under "Telescopes"). If he is doing his job right he will check each scope he sells, provide good service, answer your technical questions, and perhaps allow you to take home a scope on a trial basis. You can at least see what you're getting before you buy it. This peace of mind is worth any extra cost involved.

Mail-order companies that specialize in astronomy products can also offer personal service (over the phone) and money-back guarantees of satisfaction. We would caution you about some (not all) mail-order firms – their prices may be heavily discounted but at a sacrifice of expert personal service. Some have limited guarantees and no after-sale service – if there is a problem you can find yourself on your own dealing directly with the manufacturer. Also, watch the shipping and packing charges!

***28. What about buying a used telescope?***

If well cared for, a used telescope should perform as well as a new one. You can find telescopes in the classifieds in local newspapers and "bargain finders." You should also check with the local astronomy club or *Astronomy*'s Reader Exchange. Two newsletters called *The Starry Messenger* and *The Cosmic Exchange* (contact *Astronomy* magazine for their addresses) are devoted to ads for used telescopes.

***29. Which telescope would YOU buy?***

This is impossible to answer. Someone who has been in the hobby for a while and who has already owned several telescopes would not select the same scope a first-time buyer would. Some people prefer the solidity and precision of a fine-quality refractor, others like the aperture and versatility of a Schmidt-Cassegrain, while others prize the light-gathering power and simplicity of a large Dobsonian reflector. There is no single best telescope. In fact, chances are the first telescope you buy will not be the last. Many backyard astronomers happily own two or three telescopes, each outstanding for a certain type of viewing.

***30. I have a child interested in astronomy. Which scope should I buy? My budget is $200.***

Avoid low-cost 500-power "department store" 50-mm and 60-mm refractors. Their poor mounts, eyepieces, and finderscopes will almost certainly make these telescopes a disappointment. The better 60-mm refractors on alt-azimuth or equatorial mounts with slow-motion controls and a decent 6 X 30 finderscope can serve as starter scopes if your expectations are well-tempered. Acceptable models are available from astronomical dealers (such as those who advertise in *Astronomy*) and local telescope stores.

But the truth of the matter is that for $200 (a common budget of parents with young astronomers), there are few telescopes on the market we can endorse. Instead, we, and many astronomy educators, usually recommend a pair of 7 X 50 binoculars combined with a set of introductory books and star atlases, a package that will cost $100 to $200. Binoculars can reveal a surprising number of celestial objects (craters on the Moon, the moons of Jupiter, deep-sky objects such as star clusters and nebulae). A year spent exploring the sky with binoculars and a star chart can teach any novice astronomer, young or old, an immeasurable amount about the sky, the identity of stars and constellations, and the locations of celestial targets. If your

# TELESCOPE PROS AND CONS

### Achromatic Refractors (60mm to 5-inch)

***Advantages:*** Economical in smaller sizes; rugged; portable; easy to aim; *usually provide sharp images.*

***Disadvantages:*** Small apertures have limited light-gathering power; larger apertures exhibit chromatic aberration.

### Apochromatic Refractors (3- to 7-inch)

***Advantages:*** Provide high-quality images near perfection; excellent for lunar and planetary viewing; fast models good for wide-field, deep-sky *viewing and photography.*

***Disadvantages:*** Relatively expensive for the aperture; light-gathering power cannot compete with that of larger reflectors.

### Equatorial Newtonian (4- to 18-inch)

***Advantages:*** Large aperture for the money; small sizes are excellent scopes for serious beginner. In f/6 to f/8 designs they are good all-purpose scopes.

***Disadvantages:*** Can be very bulky and heavy in sizes over 8-inches; mirrors require adjustment; mirror surfaces are exposed and can get dirty.

### Dobsonian (8- to 20-inch)

***Advantages:*** Biggest aperture for least money; portable for the aperture; superb for deep-sky observing, easy to set up (no polar alignment); great for dark sky sites.

***Disadvantages:*** Optical quality in low-cost models is a compromise; mount does not track the stars; mirror collimation critical in fast f/ratio models.

### Schmidt-Cassegrain (4- to 14-inch)

***Advantages:*** Very portable for an equatorially-mounted scope; easy to set up and aim; adaptable for astro-photography; expandable systems with many accessories; excellent general-purpose telescopes.

***Disadvantages:*** Outperformed by specialized telescopes for planetary (refractors and long-focus Newtonians) and deep-sky viewing (large Dobsonians); corrector plates attract dew.





Earth's atmosphere absorbs almost all the ultraviolet light arriving from other celestial bodies. A telescope in space, equipped for ultraviolet observations, is therefore necessary for the study of objects detectable in this important region of the spectrum. In particular,

HST is the most powerful telescope ever launched for ultraviolet astronomy.

# The Snow Telescope

## The First Telescope Devoted to the Sun

by Lenny Abbey

George Ellery Hale, the astronomer who gave the world its largest telescope four times, was an astrophysicist at heart. His specialty was the Sun. His first really large telescope was the 40" Yerkes refractor. But he soon found that this telescope fell short of the ideal instrument for solar research. The focal length was not sufficient to provide the large image which he needed for his work.

How do you obtain a longer focal length than that of the world's largest telescope? Well, one way is to make the telescope stationary, and feed the Sun's rays into it by means of rotating mirrors. By using an arrangement of two mirrors (called a coelostat) the image could be kept in its proper orientation as it moved across the sky. The heavy instrumentation could be mounted on concrete piers, since it did not need to move.

Hale used as his site a promising location atop Mt. Wilson, in southern California. Using money from a grant by Miss Helen Snow, the mirrors were produced by George Ritchey. The parts were carried to the top of the mountain by mules, along a track which was at places only two feet wide! The telescope was mounted on two heavy rails, 150 feet in length. The whole assembly was protected by a long wooden building. Two main mirrors were provided, one with a focal length of 60 feet provided a solar image 7-inches across. The other, with a focal length of 143 feet, gave a 16-inch image.

The Snow telescope soon proved to be successful beyond Hales wildest dreams. He was soon able to demonstrate that sun spots were cooler than the photosphere, and that they were the centers of vast cyclonic storms. Their relationship to solar flares was apparent.

The telescope produced a number of "firsts." It was the first truly successful stationary telescope. It was the first telescope totally devoted to the study of the Sun. And it was the first major instrument produced by Ritchey, who later produced the optics for the 60" and 100" telescopes.

### Resolution Improvements In Ground-Based Telescopes

Although HST will remain the premier observatory for high resolution studies of astronomical objects, new techniques are being used with ground-based telescopes that will allow them to compete with HST even in resolving power. However, these techniques only work for bright star-like objects. They also work only for small patches of sky, a few arc seconds across, near the center of the telescope's field of view. This means that these techniques will not work for studies of extended targets such as star-forming nebulae.

### Active Optics, Adaptive Optics

If you look at a star on any clear night, it appears to twinkle. Light from the star passing through the turbulent atmosphere is shifted slightly by parcels of air moving to and fro thousands of times per second. By the time the light reaches the eye, or the telescope, the dancing of the light causes the image to blur into a spot about one arc second wide.

New technologies can sharpen these stellar images by distorting a telescope's mirror to compensate for blurring, or by extracting the blurring later using image processing. In active optics, the shape of the telescope mirror is adjusted hundreds of times per second to cancel the distortions caused by the atmosphere. In adaptive optics, the telescope mirror is moved thousands more times per second to follow the dancing image of the star and keep it focused into a small spot. This technique requires a reference source, either a bright star located in the vicinity of the celestial target or an "artificial star" created by reflecting a laser off selected layers in the atmosphere.

By contrast, Hubble's images and other data are optically stable so that astronomers can revisit a target at any time of year and expect the same quality data. This assures a repeatability that is not possible with adaptive optics on ground-based telescopes. An enormously complex ground-based system would be required to match HST performance. Such a system does not currently exist, and could be a decade away – beyond the working lifetime of HST.

### Speckle Interferometry

By taking many short exposures in succession rather than one long-time exposure, the effects of atmospheric turbulence can be "frozen." A computer combines each image by shifting it to a common center. This subtracts the blurring effects and recovers the telescope's best resolving power. For ground-based Mt. Palomar's 200-inch mirror this is an improvement from 0.4- at best to 0.02-arc seconds.

### Location

Because HST is a space-based observatory, it is the only telescope that can view any celestial target located anywhere in the sky unhindered by either the Earth, Moon or Sun. Keck is located at an ideal observing spot near Earth's equator, allowing it to observe most of the celestial sphere. However, stars and galaxies located near the north and south celestial poles (below 30 degrees altitude from Hawaii) are inaccessible.

The ultraviolet region is a gold mine. The most common elements in the universe – hydrogen, helium, carbon, nitrogen, oxygen and silicon – all leave spectral signatures in the ultraviolet. Ultraviolet light typically radiates from extremely hot, dynamic phenomena, such as cores of active galaxies, quasars, energetic stars, and vast disks of dust around black holes. For those looking through HST's ultraviolet window, a wealth of science about many mysterious sources of energy is open.

### An Advantage of Space-based Ultraviolet Astronomy

A broad range and variety of objects in the universe radiate energy at ultraviolet wavelengths, including the atmospheres of most stars, the surfaces of stars far more massive than our Sun, white dwarfs and hot regions of interstellar gas. However,





prospective astronomer is still interested in the hobby after a year of binocular stargazing, then purchase a decent telescope for $400 to $500. At that point you will be more confident that your money will be well-spent.

### What Can I See?

What you can see through the eyepiece of a good telescope is enough to keep you exploring the sky for many years. Here's a bit of advice: when you unpack your first telescope and set it in the backyard on its premiere night under the stars, the first thing you should look at is the Moon. You won't need high power – 50X will be just fine. Even at this low power, you'll be amazed at the view, we guarantee it.

After observing the Moon, the first planet you should look at is either Jupiter or Saturn. (If it's winter or spring try for Jupiter; if it's summer or autumn try Saturn – the monthly "Sky Almanac" section of *Astronomy* will tell you where to find them).

When you aim your scope at Saturn, be prepared for a remarkable sight. Most people utter an exclamation of "Wow!" when they first see Saturn and its picture-perfect rings.

Even a small 60-mm aperture telescope will reveal the cloud belts on Jupiter. Over the course of several nights, you'll see Jupiter's four large moons as bright dots shuttling back and forth from one side of Jupiter to the other.

A telescope also allows you to follow the changing phases of Mercury and Venus, and to watch Mars grow and shrink in size as we approach then recede from the Red Planet every two years. And, yes, Mars really does look orange-red. When it is closest to Earth, a magnification of 100X to 200X will show its reddish disk, dark surface markings, and famous polar caps. You can continue to tour the solar system by tracking down Uranus and Neptune, although even in large telescopes they appear only as tiny blue-green dots.

Starlike Pluto is within reach of backyard scopes but requires at least an 8-inch aperture instrument and dark skies.

Beyond the solar system there are hundreds of star clusters, nebulae, and galaxies within reach of 60-mm- to 80-mm aperture scopes. Larger scopes reveal these deep-sky objects in even more detail and bring thousands more deep-sky wonders within reach.

However, don't expect to see the colors you see in photographs – the colors of nebulae and galaxies are so faint they show up only in long-exposure photographs. Most deep-sky objects appear as misty, gray patches of light. However, some stars show colors your unaided eye cannot see, and many stars that appear as single to the naked eye appear split into two or more stars through a telescope – they are systems of alien suns orbiting each other.

If you want an idea of how far you can see with a telescope, you can actually explore the most distant reaches of the cosmos by hunting down elusive galaxies. Because of their immense distance, these islands of stars are typically very faint. Nevertheless, from a dark rural site a 3- or 4-inch telescope will show many of these ghostly spots of light, enabling you to probe tens of millions of light-years into space. All with a telescope costing no more than a round-trip air fare to Europe. It's a bargain price for a ticket to the stars.

### Buyer's Checklist

Does the scope have sufficient aperture? We suggest at least a 4-inch telescope for viewing for deep-sky objects.

How good are the optics? Will the dealer provide a guarantee of satisfaction?

How steady is the telescope? After a light tap, vibrations should damp out in 1 to 2 seconds.

How portable is the telescope? Can you carry it easily? Will it fit in your car?

How easy is it to set up? Is the mount complicated? Heavy? Does it require tools?

Does it have a drive motor? Is it AC or DC? DC drives can run directly from batteries and have a wider range of speed controls.

Does the mount have slow-motion controls? These make it easier to aim the scope and follow objects.

Does it have a separate finderscope? Finders that sight through the main optics are usually very poor.

How large is the finderscope? A 25-mm aperture finder is poor, a 30-mm OK, a 50-mm apeture finder such as an 8 X 50 is best.

What diameter eyepieces does it come with? 0.965-inch-diameter models are usually of poor quality. 1.25-inch diameter eyepieces are better and are available in a wider range of focal lengths and designs.

How good are the eyepieces? Orthoscopic and Plössl eyepieces (often included as standard equipment) are better than Kellner eyepieces which in turn are better than the poor Huygenian eyepieces included with many import scopes.

Does it come with a case? It's useful if you will be transporting the scope.

How expandable is the telescope? Is there a good array of accessories available?

Does it come with a warranty? And who will honor the warranty with service?

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# HUBBLE VS. NEW GROUND-BASED OPTICS

## NASA Fact Sheet, August 1993

The Hubble Space Telescope (HST) represents an historic leap forward for optical and ultraviolet astronomy. However, the aberration in the HST's primary mirror has led many to claim that powerful new ground-based telescopes will equal or surpass HST's performance. On the other hand, when optically corrected after the Servicing Mission in late 1993, the sensitivity of HST to very faint objects will increase by about 10 times. Each type of telescope offers astronomers unique strengths. Astronomy will make its mark on history with a combination of advanced ground-based systems and the restored Hubble Space Telescope.

How are new technologies improving the performance of ground-based telescopes? What science can only Hubble do?

Two features of telescope design are crucial in comparing the capability of ground-based telescopes: resolving power and light gathering power. Location also is a key factor which in many cases outweighs the differences in resolving power and light gathering power of telescopes.

### Light Gathering Power

One measure of a telescope's capability is light gathering power. The bigger the area of a lens or mirror, the more light from an object that can be captured and focused to make a brighter image. For cameras, it's the f-stop which controls how much area of the lens is available: The more area (lower f-numbers), the shorter the exposure needs to be to form an image. Because astronomers study very faint objects in the sky, they need telescopes with as big an area as possible to collect and concentrate light into an image.

The most light-hungry instruments are the spectroscopes which take the incoming light and split it into an array, like colors of the rainbow, called a spectrum. With these spectra scientists can tell what kinds of atoms and molecules are found at very great distances or far back in time and how hot and how fast they are moving.

The world's largest telescope, the W.M. Keck telescope in Mauna Kea, Hawaii, instead of one mirror, is made of many individually controlled, hexagonal mirror segments. Keck's multi-mirror array has a 10-meter (33-foot) aperture. This colossus has 17 times more light collecting area than HST's 2.4-meter (7-foot) mirror. Consequently, Keck's "light bucket" is significantly faster at collecting faint starlight. This makes the Keck telescope a powerful instrument for performing spectroscopic studies of faint objects; it could gather spectral data from astronomical sources much more quickly than Hubble.

### Resolving Power

Resolving power or resolution is the ability to yield sharp, detailed images. An optometrist calls this "visual acuity". In theory, a telescope's resolving power improves as the diameter of the telescope's mirror or lens increases. However, the blurring of starlight by Earth's atmosphere prevents telescopes from realizing their theoretical potential.

Ground-based telescopes can resolve detail about 60 times better than the human eye. Keck's larger mirror array is limited by the atmosphere to a resolving power of about .5 arc second. HST, located high above the Earth's atmosphere, has a resolving power that is 5-10 times better. This means that the HST can concentrate starlight into much smaller spots and separate objects that are much closer together than the Keck can.