



Outfitting the Compleat Astronomer!

Everything You Need to Observe in Style and Comfort!

Michael W. Masters



***The Compleat
Astronomer***



***The Compleat Angler
Isaac Walton, 1653***

Setting Expectations

- **The talk deals strictly with accessories**
 - Hopefully you already have a scope and mount!
 - Astrophotography is not covered
- **The products discussed herein are items that I own or have owned or are similar to products that I own**
 - Other related products would work just as well
- **I don't own shares in or have a relationship with any company that makes or sells astronomy gear**
 - I do, however, sometimes tell people what I think about their stuff – and occasionally the result shows up in a later release of the product!
- **Accessories aren't a substitute for a good scope and mount, but they can enhance the observing experience**





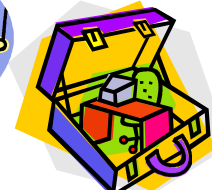
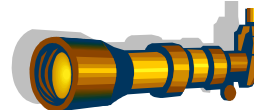
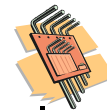
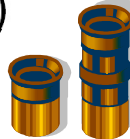
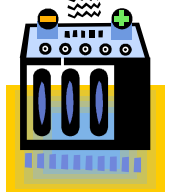
Gear Choices for Amateur Astronomers

- Setting up the scope, aligning & calibrating the mount, etc.
- How does one get power to the mount and accessories?
- What does one look for? (star charts, observer guides)
- Finding objects (finder scopes and unit power finders)
- Getting a good view of objects in the sky (eyepieces, filters)
- What do you do if you wear glasses?



Observing comfortably (chairs, stepstools, tables)

- Having the right accessories (e.g. red flashlight)
- Remembering to pack accessories you don't think of until it's too late (batteries, fuses, tools, spare parts, etc.)
- Keeping the scope dry on humid nights
- Staying warm (or bug free, etc.)
- How do you keep the optics clean?
- What can you do with a computer?
- Where **DO** you put all that stuff!!?



✱ Especially difficult for beginners

Getting Started



Orion case with cubed foam

Pelican case



Compass w/magnetic declination offset



Fredericksburg is 10 deg West

<http://www.ngdc.noaa.gov/geo/magmodels/Declination.jsp>



Carpenter's pitch level



Horse tack box



Sleeve potholder



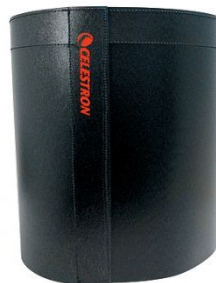
GEM Counterweights



Coleman
Dynasty (30"x60")
Tailgater (48"x32")
folding tables



Starmaster light shroud
& transport handles



SCT Dew Shield



Shake
Enders



Cabela's
recliner

Outfitting the Compleat Astronomer!

Observing Chairs and Stepstools



“Drum throne!”



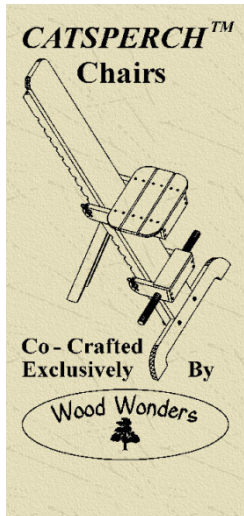
Starbound
chair



Stardust chair



Cosmo Comfort



CatsPerch
Chair



StarStep by Starmaster



Cosco Stepstool
“Magic Fold”



Observer's Ladder
Melbourne Observatory
Museum

Finder are Essential – Which is Easier to Use?



Hint: Can you contort your neck like a great blue heron?

Finder are Essential – Which is Easier to Use?



Finding objects in the sky is one of the most difficult tasks for beginners
...and right angle finders are *MUCH* easier to use!!

Just Say 'No' to Wimpy Finders!

**SKY
& TELESCOPE**

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FOCAL POINT

Ticked Off About Telescopes

IN THE FEBRUARY 1991 issue, page 124, several editors of *Sky & Telescope* revealed what irked them most about certain commercial products: right-angle finders, expensive eyepieces, and short-focus apochromats. The following pet peeves are from our readers. Although no one telescope will satisfy everyone's needs, most amateurs will agree that some could stand improvement.

Department-store telescopes. Recently a novice amateur astronomer excitedly showed me his new telescope — a 2-inch, "400×," department-store refractor. The telescope didn't include a wide-field eyepiece, and the mount was so sloppy that it was nearly impossible to bring Saturn into view — even though the mount came with slow-motion controls. Although I could resolve the rings, the image was very soft and showed much spurious color.

My friend was impressed with the image, as most people who see Saturn for the first time are. Only after he tried to center Saturn did he realize that this "quality" telescope had serious shortcomings. I finally acknowledged that no amount of practice on his part would overcome the telescope's optical and mechanical problems.

A poor-quality 2-inch refractor on a sloppy mount does more to discourage interest in astronomy than perpetually cloudy skies. We need an attractive alternative to the department-store sham scopes. Many people who are ready to move beyond binoculars are often not prepared or able to spend much money on a telescope.

ANDRE BORMANIS
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Large Newtonians. The trend toward larger and larger reflectors is indeed exciting, and I can understand the need to keep them short-focus (typically f/4 to f/5). But why are so many small ones

also made with these focal ratios? Such telescopes bring out the worst in the Newtonian design. The 6-inch f/8s and 8-inch f/7s, common many years ago, were much better and more versatile reflectors than many commercially available today.

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Unreal eyepieces. Eyepieces match characteristics of telescope objectives with those of the observer's eye. Yet, until recently, designers attempted to minimize aberrations as if their eyepieces were stand-alone optical systems. At least some designers have now acknowledged that an objective lies in front of the eyepiece and have made available a few types of eyepieces that are matched to specific telescopes. However, I would hazard a guess that not one eyepiece design in a hundred takes into account the optical system that lies behind it — that is, the human eye — whose aberrations become rather pronounced when the iris is fully open.

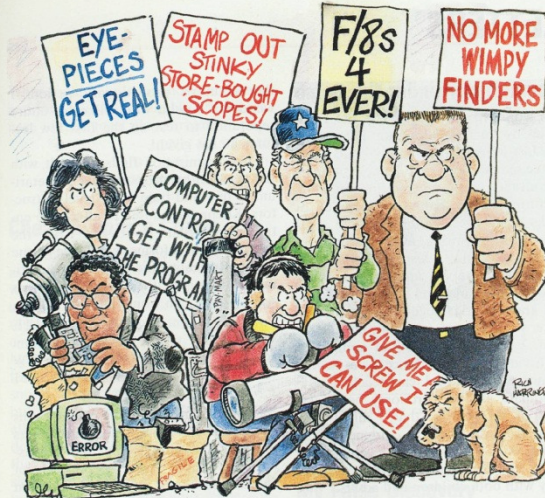
MICHAEL RUDENKO
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Tiny screws. Why are finders held in position by three screws with tiny heads that cannot be adjusted while wearing gloves or mittens? How many observing sessions end before they begin, as the discouraged observer goes indoors with frozen fingers?

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Astro Masters. Why do digital guiding systems have databases that include objects across the entire northern and

What irks me are finders with anemic light grasp and puny fields of view. The standard 8×50 finders on commercial Schmidt-Cassegrain telescopes are at the bottom of my acceptable limit.



southern celestial hemispheres? (Not everyone can travel.) Logically such a system can only be fully utilized by someone observing near the Equator. All other users living or observing from temperate latitudes can use only a fraction of the data.

There should be three versions of the Astro Masters. Aside from the original, there should be ones specialized for Northern and Southern Hemisphere observers. More objects could then be included that would benefit the user.

When Dennis di Cicco delivered his extensive *Advanced Astro Master* test report (S&T: May 1990, page 499), he wrote: "The fact that updates are so easily made is comforting to anyone worried that the unit will soon become obsolete." With this statement in mind, it should not be too difficult to create various databases.

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Computer-controlled telescopes. There seems to be a great need for bolt-on computer control systems, especially for the mass-market Schmidt-Cassegrains. Several manufacturers offer expensive "black boxes" — programmed with their choice of objects — that neither connect to PCs nor slew telescopes automatically.

Many amateurs, I'm sure, would like to control their telescopes using their own computers. All we really need are a plug-in circuit board, shaft encoders, slewing motors, and suitable software. These all appear to be available in subsets but not as an integrated whole.

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Wimpy finders. What irks me are finders with anemic light grasp and puny fields of view. The standard 8×50 finders on commercial Schmidt-Cassegrain telescopes are at the bottom of my acceptable limit. The ideal finder would be an 80-millimeter f/5 refractor coupled to a 32-mm eyepiece with a 2-inch barrel. This finder would yield 12½× and a 5° field of view — perfect for an exit pupil of 6.4 mm. I would top it off with a 2-inch Amici diagonal for correctly oriented images. Regrettably, I have never seen this accessory advertised. Nor have I seen anyone offer a 32-mm illuminated-reticle eyepiece 2 inches in diameter.

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Do you have a pet peeve? Send it to Focal Point, Sky & Telescope, P.O. Box 9111, Belmont, MA 02178-9111.

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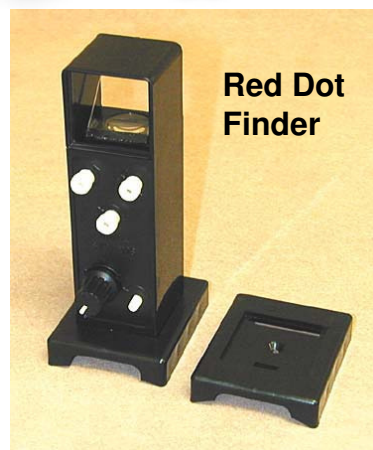
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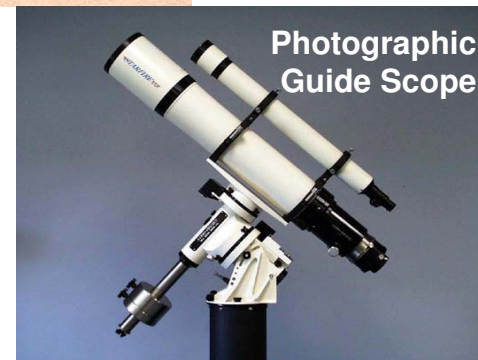
ON THE COVER:

Shortly after the Hubble Space Telescope (HST) was launched in April 1990, horrified astronomers found it to suffer from an optical defect known as spherical aberration. In early December NASA hopes to show it still has the "right stuff" by repairing HST in orbit 575 kilometers above Earth. Here artist Scott Kahler depicts the telescope berthed in the Space Shuttle *Endeavour's* payload bay while two space-walking astronauts install a package of corrective optics called COSTAR. On page 16 technical editor Richard Tresch Fienberg explains the mission's objectives in detail, and on page 24 *Endeavour* crew member Jeffrey A. Hoffman offers an insider's preview of the daring flight. Artwork courtesy: Ball Aerospace and Communications Group.

Finders & Other Accessories







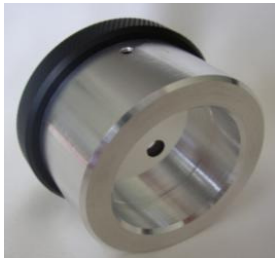



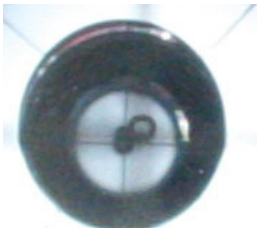
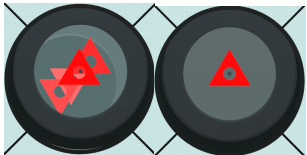
←
Unit
Power
Finders



* 8x50x5° is a “sweet spot” for finders

Outfitting the Compleat Astronomer!

Newtonian Collimation Tools

				
1.25" Laser with view window	Sight Tube w/ crosshair	2" Laser w/o view window	Cheshire eyepiece	Auto-collimator w/mirrored inside surface
 2" to 1.25"		Iterate		Iterate
Secondary & primary mirror alignment	Initial evaluation & secondary centering			
		Secondary alignment (rotation & tilt) 	Primary mirror alignment 	Final optical path closure (secondary mirror) 

Program presentation "Collimating Newtonian Reflectors: Tools & Methods" is available in PDF format on RaClub.org under [Documents > Programs](#).

Powering Astronomy Gear



BatteriesPlus 35-AH
12 volt SLA AGM Battery



Orion 12-volt 12 AH
Power Station



Xantrex DC-to-AC
140W Square
Wave Inverter



Samlex DC-to-AC 300W
Pure Sine Wave Inverter



13.8-volt AC-to-DC
Power Supply (5A)



12-volt DC
Socket



12-volt Digital
Voltmeter



12-volt Digital Voltmeter
and Socket Multiplier



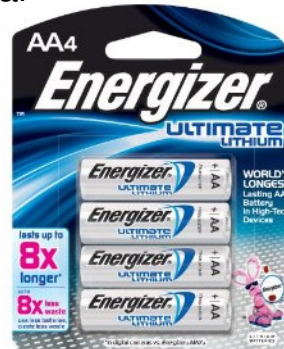
Battery Guard
shutoff @ 10.7V



Auto Lighter Plug



1-to-3 Socket Adapter



Glass-type
Fuses



Blade-type
Fuses

Dew Heaters and Other Stuff



Red Laptop Screen
AstroSightSaver.com



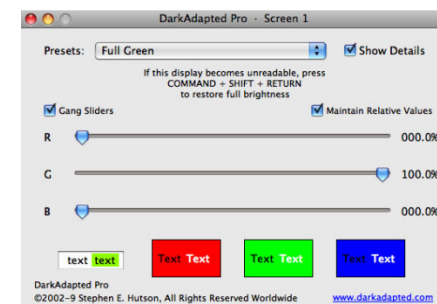
USB-to-DB9 Serial
Adapter Cable



Thousand Oaks
Heater Controller



Kendrick Dew
Heater Controller



aquiladigital.us/darkadapted/



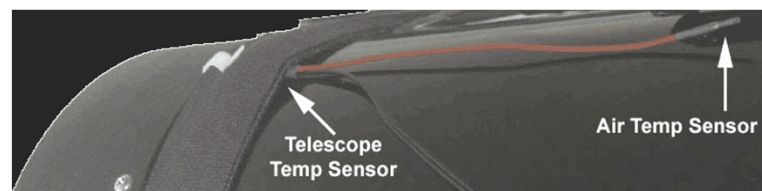
DewBuster Controller &
Temperature Sensor
for Dew Heater Strips



Dew-Not Dew Heater



Kendrick Dew Heater



Outfitting the Compleat Astronomer!



Kendrick Laptop Heater
(good for eyepieces too!)

Tools You Didn't Know You Needed Until It Was Too Late



Nite Ize LED Light



Rigel Two-Color Flashlight



Orion Green Laser
(Do not point at aircraft!)



Rayovac LED Headlamp
Lifetime warranty!



Multi-Tool



Spare Parts



Magnifying Glass



Allen Wrench Set
in Metal Case



Eyeglasses Cord



Susie's Favorites!



Eyeglass Repair Kit



Eye Patch



Tools You Didn't Know You Needed Until It Was Too Late



Bicycle
Safety
Light



Rigel Two-Color
Flashlight



Orion Green Laser
(Do not point at aircraft!)



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Susie's Favorites!

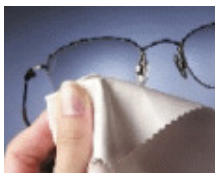


Eyeglass Repair Kit



Eye Patch

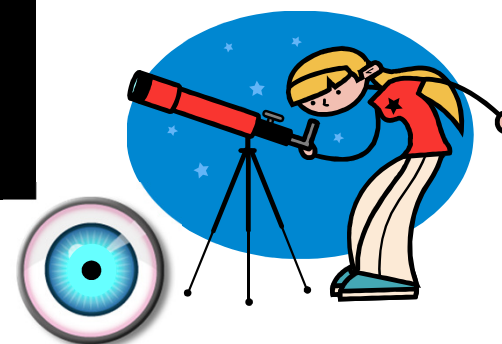
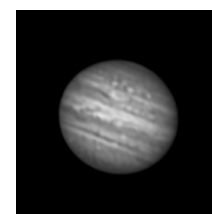
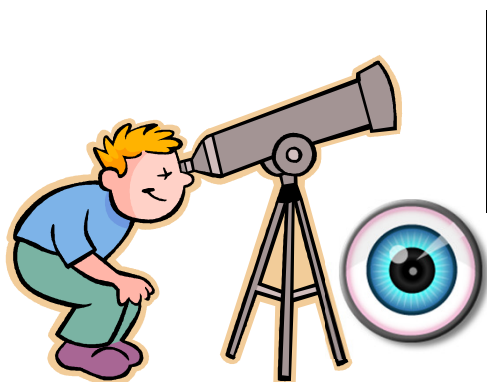




Notes for Glasses Wearers



- Eye relief of $\sim 20\text{mm}$ is needed to accommodate glasses
 - Focuser travel will accommodate distance correction provided by glasses
- Image quality of the eye depends on the diameter of the eye pupil
 - Large eyepiece exit pupils reveal eye aberrations such as astigmatism
 - Very small eyepiece exit pupils reveal eye defects such as floaters
- Most observers with astigmatism find they must wear their glasses when viewing at low powers and correspondingly large exit pupils
 - Eye glasses correct for astigmatism but require long eye relief eyepieces
 - Corrective optics may also be used on the eyepiece, e.g. TeleVue Dioptrix
- Higher power eyepieces use a smaller portion of the eye, reducing the effects of astigmatism and eliminating need for glasses
 - If the eyepiece exit beam is small, only that much of the eye is used



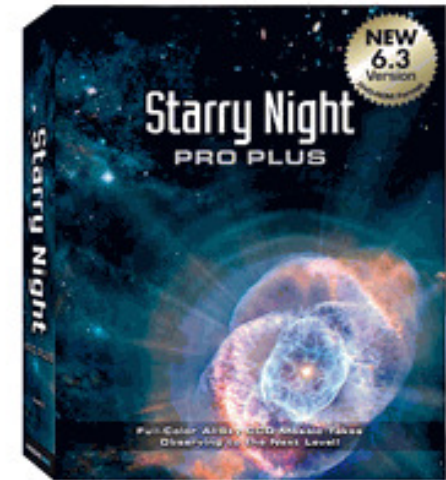
Astronomy Software



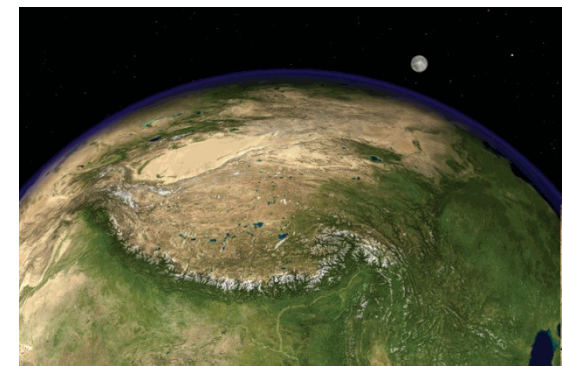
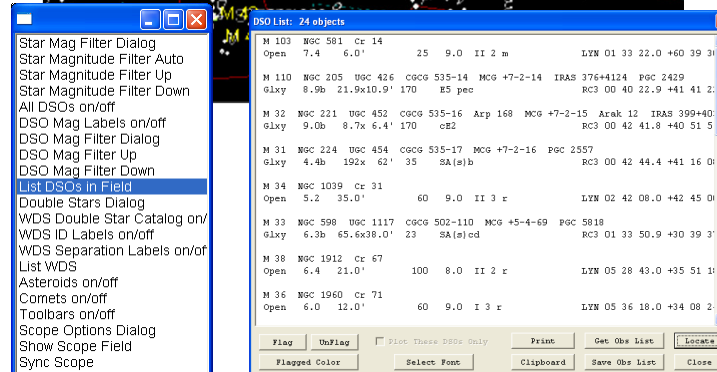
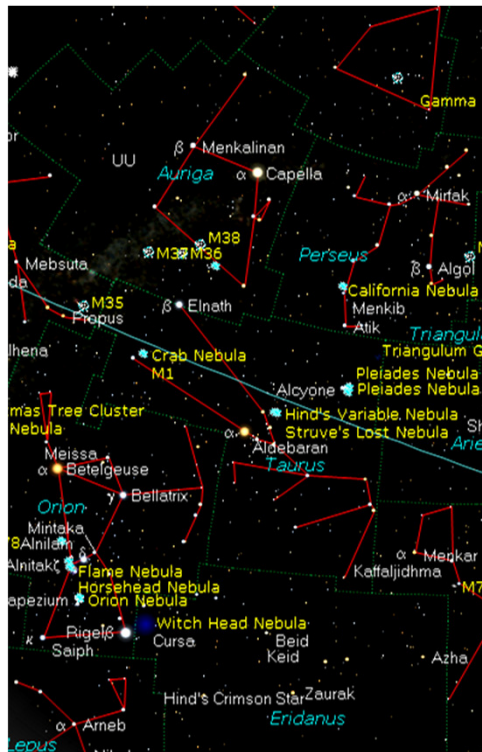
\$99 – \$279



\$130



\$50 – \$250



Keep Warm With Layers!



Ragg Wool
Fingerless
Gloves

Polypro Base Layer



Foot Warmer



Say
No
To
Sprays



Cabela's Berber Fleece

Fleece
Glove Mitts

Ragg Wool
Balaclava



Fleece Hood



Mad
Bomber Hat



Cabela's Wooltimate
Fleece Vest



Swedish WoolPower



Sunscreen
+ Bug Lotion

Smart-
Wool
Socks



Polypro
Liner
Socks

**Fleece
Wool
Down
Polypro
Thermax
Thinsulate**



Hand/Foot Warmer



Down
Camp
Boots



Bug Towelettes



Deer
Stand
Booties

Outfitting the Compleat Astronomer!

Kodak Lens
Tissue



Optics Cleaning Supplies

Lens Clens



Photographic Solutions
Eclipse Cleaning Fluid



PEC PAD
Lint Free Wipes



Sensor Swabs



Microfiber
Cloth

Visible Dust
Sensor Loupe



Baader Optical
Wonder



Purosol *



Kinetronics Brush
(Anti-static)

Bulb Blower



CO2 Cartridge



http://www.astro-physics.com/tech_support/refractors/care_of_scope_instructions070506.pdf
<http://www.astro-physics.com/products/accessories/cleaningproducts/optics-instructions.pdf>

* Developed by NASA

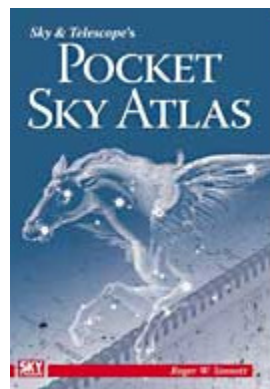
Star Charts and Atlases



\$30 – 6.5 – 8800*+ – 600+



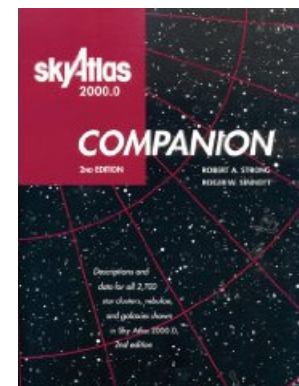
\$10 – 6.5 – 8833* – 600+



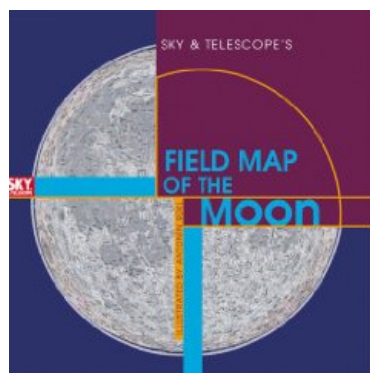
\$14 – 7.6 – 30,000* – 1500



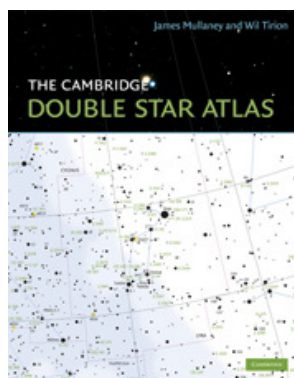
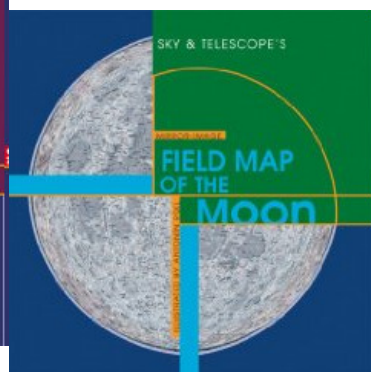
\$38 – 8.5 – 81,312* – 2700



\$20 – 2700 objects



\$9+ ea



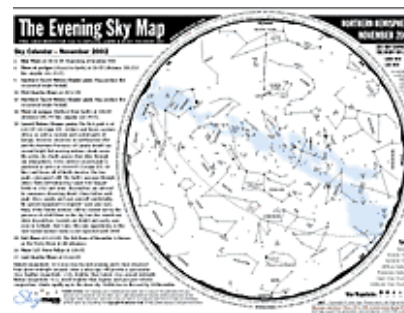
\$23 – 7.5 – 25,000* – 900



\$35 ea – 7935 objects



\$11

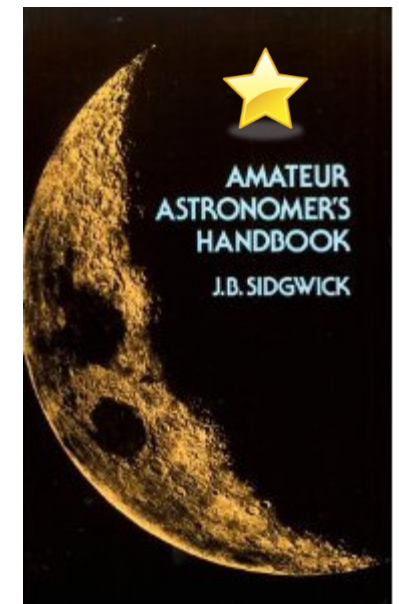
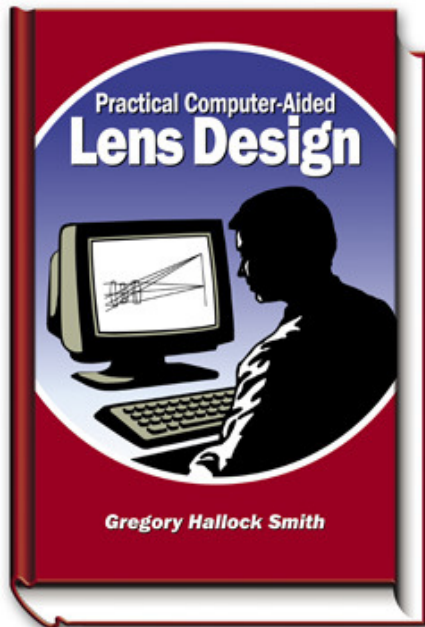
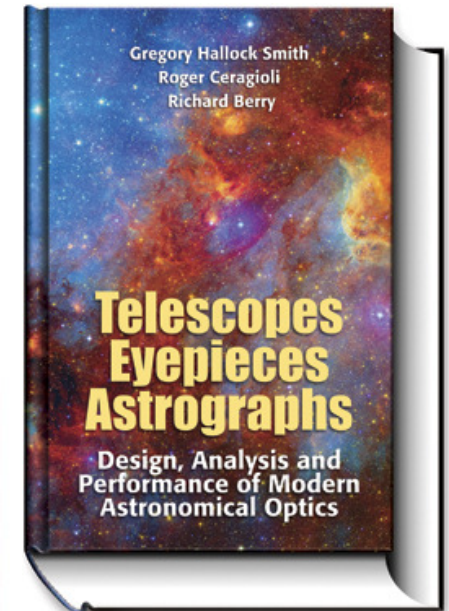
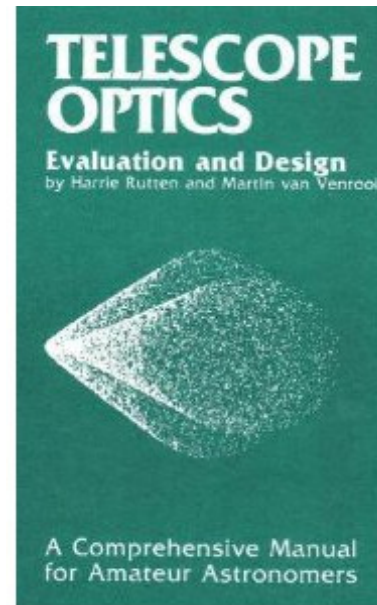
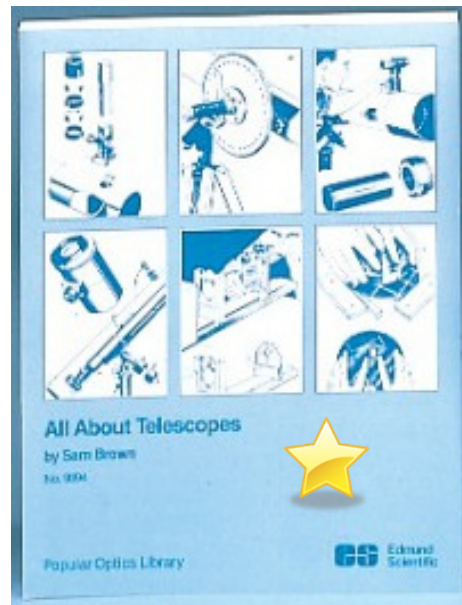
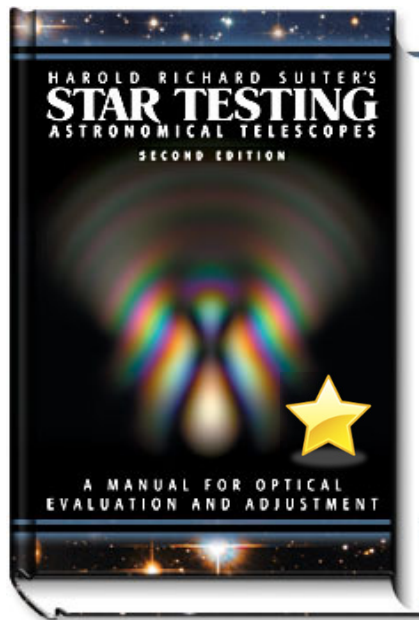


\$50 ea – 9.75 – 280,000* – 30,000
June 2012

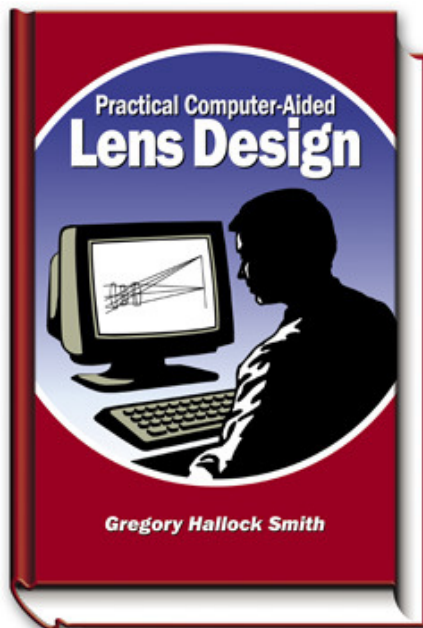
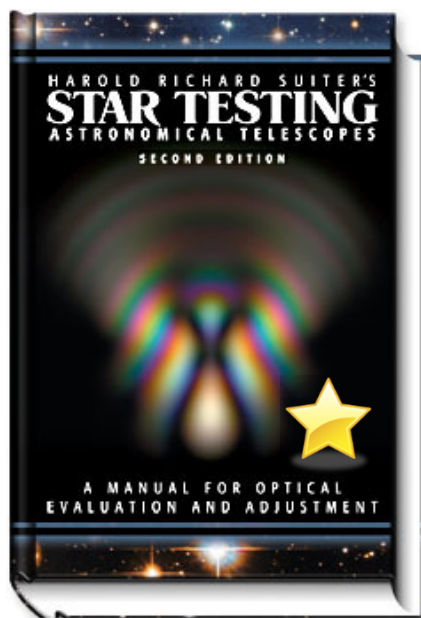
Outfitting the Compleat Astronomer!

See SkyMaps.com for more choices

Telescope Optics



★ Gold Star rating is for practicality!



Telescope Optics

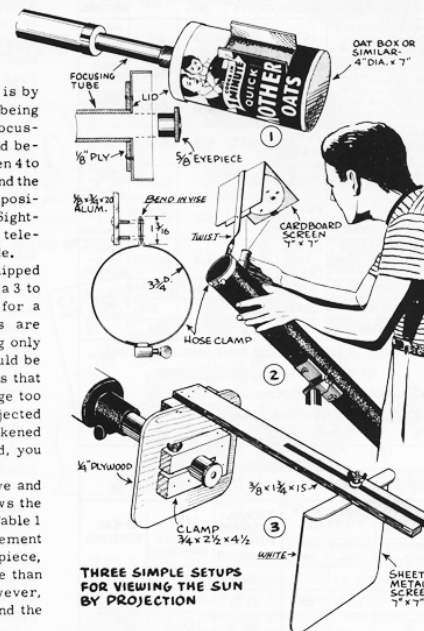


OBSERVING THE SUN

THE SAFE and sane way to observe the sun is by projection. Equipment for this is simple, being merely a cardboard shade slipped over the focusing tube and a piece of white cardboard held behind the eyepiece. Hold the cardboard screen 4 to 6 inches behind the eyepiece and then extend the eyepiece just a little from normal infinity position to focus the sun's image on the screen. Sighting is done by watching the shadow of the telescope tube on the ground or on the sunshade.

A simple setup is a round cereal box slipped over the focusing tube, Fig. 1. This allows a 3 to 4-in. sun image, which is about normal for a small telescope. Other equipment ideas are shown in Figs. 2 and 3. With any setup using only a simple sunshade, the enlargement should be between 10x and 20x. The situation here is that you are in open daylight, and if you enlarge too much the daylight will wash out the projected image. With a closed box, or inside a darkened room or with a cloth thrown over your head, you can go up to 50x enlargement.

Assume for example 30 in. f.l. objective and desired enlargement of 15x. Table 2 shows the image will be 4-1/16 in. diameter. Then, Table 1 shows the "throw" needed for 15x enlargement using various eyepieces. With 5/8 in. eyepiece, the throw is 9-7/8 inches. This is a bit more than provided by the oat box setup, Fig. 1. However, you can get 10x easily (6-7/8 in. throw), and the



THREE SIMPLE SETUPS FOR VIEWING THE SUN BY PROJECTION

SUN PROJECTION DATA

CAUTION: INTENSE HEAT CAN DAMAGE CEMENTED EYEPIECE LENSES - USE ARMSDEN OR HUBBARD, ESPECIALLY WHEN (1) SUN IS BRIGHT, OR (2) OBJECTIVE IS OVER 3" DIAMETER

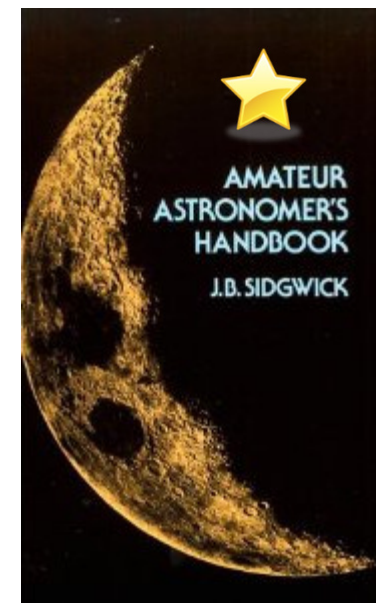
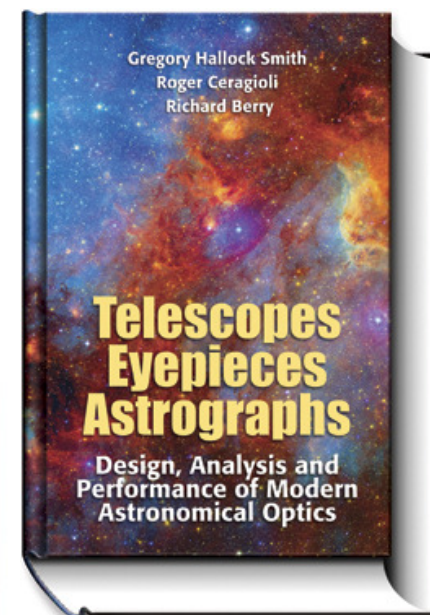
PROJECTION MAG.	1/4"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"
5x	1 1/2"	3"	3 3/4"	4 1/2"	5 1/4"	6"	7 1/2"
10x	2 3/4"	5 1/2"	6 7/8"	8 3/4"	9 3/4"	11"	13 3/4"
15x	4"	8"	9 7/8"	12"	13 3/8"	16"	20"
20x	5 1/4"	10 1/2"	13"	15 3/4"	18 1/4"	21"	26 1/4"
30x	7 3/4"	15 1/2"	19 1/4"	23 1/4"	27"	31"	38 3/8"
40x	10 1/4"	20 1/2"	25 3/8"	30 3/4"	35 3/4"	41"	51 1/4"
50x	12 3/4"	25 1/2"	31 3/8"	38 3/4"	44 3/4"	51"	63 3/4"









*WILL NOT COVER FULL DIAMETER OF SUN



OBJECTIVE F. L.	PRIMARY IMAGE	5x	10x	15x	20x	30x	40x	50x
20"	.180"	7/8"	1 3/8"	2 1/8"	3 1/8"	5 1/8"	7 1/8"	9"
30"	.271"	1 1/8"	2 1/8"	4 1/8"	5 1/8"	8 1/8"	10 7/8"	13 3/8"
40"	.361"	1 3/8"	3 1/8"	5 1/8"	7 1/4"	10 1/8"	14 1/8"	18 1/8"
45"	.405"	2"	4 1/8"	6 1/8"	8 1/8"	12 3/8"	16 3/8"	20 1/4"
48"	.432"	2 1/8"	4 3/8"	6 3/8"	8 3/8"	13"	17 1/4"	21 1/8"
50"	.451"	2 1/4"	4 3/4"	6 3/4"	9"	13 1/2"	18"	22 1/2"
60"	.541"	2 3/4"	5 1/4"	8 1/4"	10 1/4"	16 1/4"	21 5/8"	27"
70"	.631"	3 1/8"	6 1/4"	9 1/4"	12 1/8"	19"	25 1/4"	31 1/2"

All about Telescopes, Sam Brown, 1967, Edmund Scientifics



iPhone, iPad App	Personal / Description	Platform	Price
SkySafari+	Star charts, object info & more (gyro) 	iPhone, iPad	\$14.99
Stellarium	Star charts (gyro)	iPhone	Free
Distant Suns	Star charts (pannable)	iPhone	Free/\$9.99
Star Charts	by Wil Tirion (static); 18 charts w/DSOs	iPhone	\$3.99
Star Atlas	Star charts (static); indexed variously	iPhone	Free
Planet Finder	Locate planets (gyro)	iPhone	Free
Planets	Locate planets (gyro, star chart bkgnd) 	iPhone	Free
3D Sun, SOHO, Sun Viewer	NASA Solar Viewers (SOHO )	iPhone	Free
MoonMapLite	Four quadrant Moon map	iPhone	Free
Mars Globe	Mars terrain & feature map	iPhone	Free
Sunrise & Sunset Lite	Sunrise and Sunset times 	iPhone	Free
Moon.	Moon rise, set and phase info 	iPhone	Free
APOD	NASA Astronomy Picture of the Day 	iPhone	Free
Space Images	NASA/JPL Space Images	iPhone	Free
Go Stargaze	NASA/JPL Night Sky Network 	iPhone	Free
iCSC, MyCSC	Clear Sky Clock 	iPhone, iPad	Free

App Survey

Application	Description	Platform	Price
SkySafari+ 2	Star charts, object info & more (gyro)	iPad, Android	\$14.99
Star Walk 1	Star charts, satellites & more (gyro)	iPhone, iPad	\$2.99/\$4.99
MyCSC 1	Clear Sky Clock	iPad	Free
Google SkyMap 3	Star charts (gyro)	Android	Free
SkEYE 1	Planetarium app	Android	Free
Planet's Position 1	Calculates planet positions	Android	Free
GPSEssentials 1	GPS navigation app (mount location)	Android	Free
Sky Week 1	Sky & Telescope app	Android	\$1.99
Lunafaqt 1	Sun and Moon info	Android	Free
Pocket Stars	Basic star atlas	HTC	
PleiadAtlas 1	Pocket star atlas	PalmPilot	
Astronomist 1	Planetarium & eclipse calculator	PalmPilot	
Planetarium 1	No longer supported	PalmPilot	
Orrery 1	No longer supported	PalmPilot	
Messier 1	No longer supported	PalmPilot	
Jovian 1	No longer supported	PalmPilot	
Moon Info 1	No longer supported	PalmPilot	

Checklists for the Forgetful Astronomer!

Astronomy Pack List

Astro-Physics 155 & 130 Refractors

Telescope case
Mach 1 or 400GTO mount
Hardwood tripod & shake enders
Eyepiece and diagonal case
Eyepiece holder wood tray
155: ZenithStar 66SD case & A-T rings
130: 8x50 finder & rings and/or Starbeam
Weights/electronics blue open tray
Werker 33 AH batteries (2)
Dew & power accessories in red bag
Laptop computer & red screen
Stardust observing chair
Star charts & GOTO instructions
Folding table 2.5' x 5'
Folding table 2' x 4'
Food, drink, clothing, clean glasses

Cold Weather Clothing

ECWCS & Woolpower thermal underwear
River Driver shirt & Wooltimate pullover
Wool sweater & vest and fleece vest
Insulated pants: fleece, windbloc, down
Columbia jacket or North Face parka
Balaclava, fleece hat, fingerless glove mitts
Liner socks: polypro, thermax, SmartWool
Wigwam, SmartWool and/or Ragg socks
Pipedragons & moon boots or down booties
Hand and foot chemical warmers

Overnight at Big Meadows

Air mattress & D-cell batteries
Sleeping bag & pillow
Folding chair
Extra 9v, AA batteries
Power inverter
Eyepiece dew sheet, cable, controller
Werker 33 AH batteries (3)
Food cooler & 3 Thermoses + flatware
Maps & weather printouts
Travel kit w/travel alarm clock
Towels

16" Starmaster Truss Dob

Rocker box
Mirror box
Mirror in box
Upper cage
Truss carry bag
Eyepiece case
Eyepiece holder
Collimation tools case
Bolts/batteries/telrad carry tray
Panasonic batteries (2 to 4)
Star charts
Starmaster & Sky Commander instructions
Eyepiece dew sheet, 33 AH, 1000 Oaks
Cosco red step stool
Folding table 2.5' x 5'
Folding table 2' x 4'
Folding cloth chair
Food, drink, clothing, clean glasses

Star Charts & Accessories

Observing list & info folders
Bright Star Atlas 2000.0
Pocket Sky Atlas
Sky Atlas 2000.0
Uranometria 2000.0
Sanner & Kepple Observer's Guides
Weather printouts
Map printouts
Garmin GPSMAP 76CSx

Astro-Physics 105 Traveler

Traveler in carry case
Vixen SkyPod mount & tripod
17AH battery & spare AA batteries
Eyepiece case (or move eyepieces)
Eyepiece holder wood tray
Bright Star Atlas, Sky Atlas 2000
Stardust observing chair
Folding table 2' x 4'
Food, drink, clothing, clean glasses

Revised 1 January 2009

Astronomy and Photography Battery Inventory

Astronomy Device	Qty	Type	Brand	Source	Spares Location	Notes
Astro-Physics Keyrads (2)	1	CR1632	Renata	Astro-Physics	Becca Room Drawer	Two replacements bought ~Jan 2007
8x50 Finder Illuminated Reticle	2	357 Button	Energizer	Batteries Plus	Eyepiece Case	Blue accessory tray, bought 1 Aug 07
TeleVue Starbeam Finder	2	357 Button	Energizer	Batteries Plus	Eyepiece Case	Panasonic LR44, SR44, bought 1 Aug 07
Starmaster Telrad Finder	2	AA	Duracell Ultra	Lowes, etc.	Reflector Tool Case	
Starmaster Sky Commander	1	9 Volt	Duracell	Lowes, etc.	Reflector Tool Case	
Starlight Red/White Flashlight	1	9 Volt	Duracell	Lowes, etc.	Tool Case & Blue Tray	
Laser Collimator	2	AAA	Eveready	Lowes, etc.	Blue Accessory Trays	Both trays
Optonics Headlamp	3	AAA	Eveready	Lowes, etc.	Blue Accessory Trays	Both trays
Green Laser	2	AAA	Eveready	Lowes, etc.	Blue Accessory Trays	Both trays

Photography Device	Qty	Type	Brand	Source	Location	Notes
Canon 550EX Flash	4	AA	Duracell Ultra	Lowes, etc.	Tamrac/Domke Bags	Quantum battery dummy
Canon ST-E2 Flash Wireless	1	2CR5 Lithium	Duracell, etc.	Batteries Plus?	Tamrac nature bag	Old spare in Tamrac nature bag
Canon Wireless LC-4 Transmitter	4	AA	Duracell Ultra	Lowes, etc.	Tamrac nature bag	Hand remote controller
Canon Wireless LC-4 Receiver	4	AA	Duracell Ultra	Lowes, etc.	Tamrac nature bag	On-camera controller
Canon Remote Timer Release	1	CR2032	Duracell Lithium	Batteries Plus	Tamrac nature bag	Spare bought 31 July 2007
Minolta Flashmeter V	1	AA	Duracell Ultra	Lowes, etc.	Tamrac nature bag	2011 use date, installed 7/29/07
Visible Dust Sensor Loupe (3)	2	CR2025	Panasonic	Batteries Plus	Cleaning Supplies	Installed June 2007, Domke FX-1

Other Devices	Qty	Type	Brand	Source	Location	Notes
Bushnell Yardage Pro Rangefinder	1	CR2 Lithium	Panasonic, etc.	Batteries Plus	Misc Photo Gear Bag	Spare bought 31 July 2007
Garmin GPSMAP 76 CSx	2	AA	Duracell Ultra	Lowes, etc.	Misc Photo Gear Bag	

Astro-Physics 155 EDFS 17 Refractor	D = mm	F = mm	f ratio =	Faintest mag =	Airy disc = arcsec	Dawes = arcsec	Double apparent *	OTA weight	Personal eye pupil
	155	1092	7	13	1.8	0.75	4	24 lb	5

Eyepiece focal length	Power X	True field deg/min	Exit pupil mm	Effective D	Double @ Apparent	Power X / inch	TeleVue Type	Apparent field deg	Field stop mm	Eye relief mm
55 mm	20	2.4	7.9	99	12	3	Plossl	50	46	38
31 mm	35	2.2	4.4	155	6.9	6	Nagler 5	82	42	19
22 mm	50	1.6	3.1	155	4.8	8	Nagler 4	82	31.1	19
17 mm	64	1.3	2.4	155	3.8	10	Nagler 4	82	24.3	17
13 mm	84	55'	1.9	155	2.9	14	Nagler 6	82	17.6	12
9 mm	121	39'	1.3	155	2	20	Nagler 6	82	12.4	12
7 mm	156	31'	1	155	1.5	26	Nagler 6	82	9.7	12
5 mm	218	22'	0.7	155	1.1	36	Nagler 6	82	7	12
3.5 mm	312	15'	0.5	155	0.8	51	Nagler 6	82	4.8	12
2.5 mm	437	11'	0.4	155	0.5	72	Nagler 6	82	3.4	12

William Optics ZenithStar 66mm SD	D = mm	F = mm	f ratio =	Faintest mag	Airy disc = arcsec	Dawes = arcsec	Double apparent *	OTA weight	Personal eye pupil
	66	388	5.88	11.2	4.2	1.8	4	3.5 lb	5

Eyepiece focal length	Power X	True field deg/min	Exit pupil mm	Effective D	Double @ Apparent	Power X / inch	Type	Apparent field deg	Field stop mm	Eye relief mm
24 mm	16	4	4.1	66	15	6.2	Panoptic	68	27	15

Eyepiece Accessories



**Adapter to use 1.25"
Eyepieces in 2" Focuser**



**Astro-Physics
Photo-Visual
Telecompressor
& Field Flatteners**



**TeleVue Paracorr
Coma Corrector
(fast Newtonians)**



**2" Barlow Lens with
1.25" Adapter**



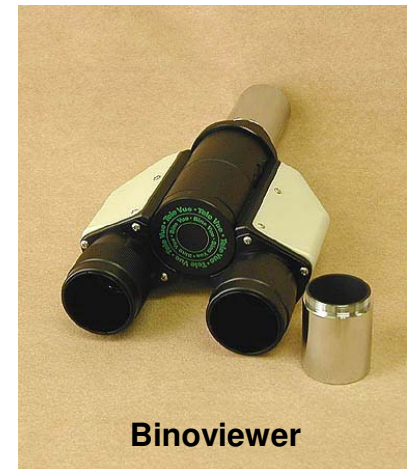
**2" Mirror Diagonal with
Dielectric Coatings**



**Eyepiece Diopter Corrector
for Eye Astigmatism
(low power eyepieces)**



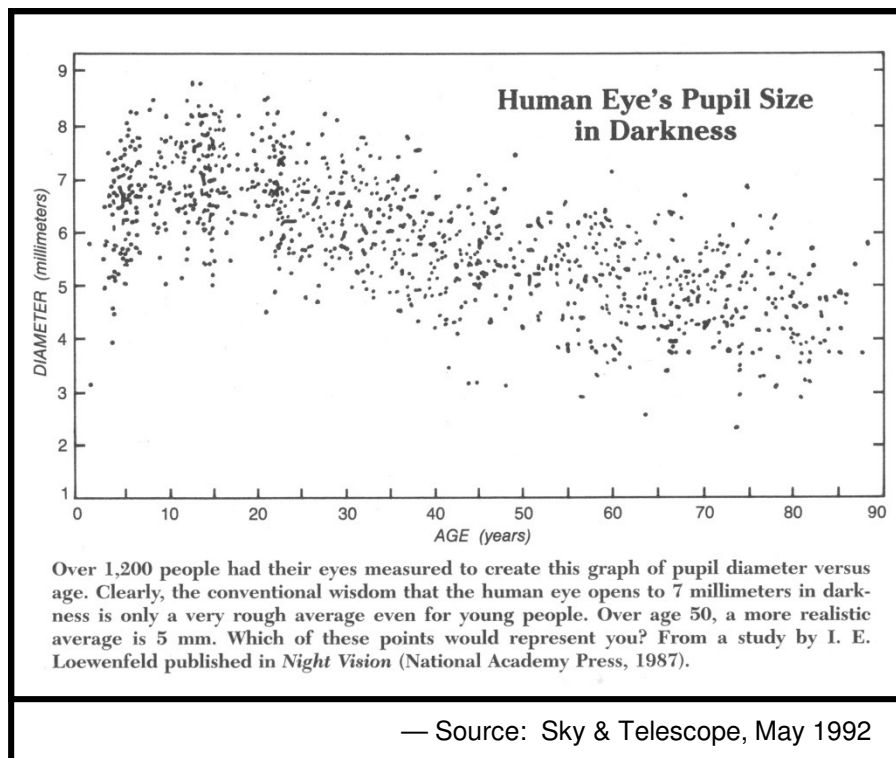
**Filters (discussed
separately)**



Binoviewer

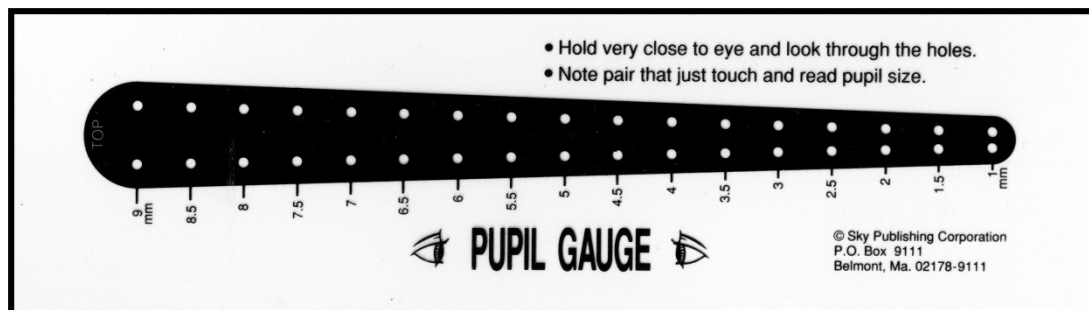
$$\text{Exit pupil} = \text{eyepiece FL} / \text{scope f ratio}$$

Eye Pupil, Age and Magnification



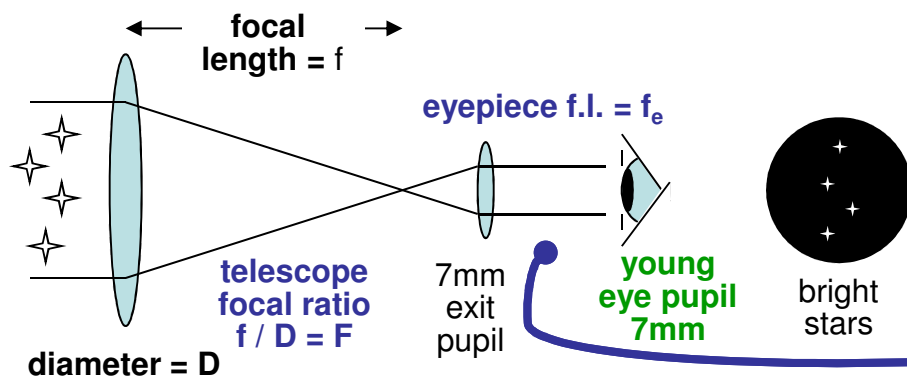
Age vs. Pupil Size and Lowest Magnification (Low power eyepieces have large exit pupils)			
Approx. Age	Avg. Pupil Size	Lowest Effective Magnification per inch of Aperture	Lowest Effective Magnification per cm of Aperture
< 25	7	3.5	1.4
30	6.5	3.8	1.5
35	6	4.1	1.6
45	5.5	4.5	1.8
60	5	4.9	2
80	4.5	5.4	2.2

— Source: Event Horizon Newsletter, April 1996, Hamilton Amateur Astronomers

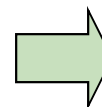


The eye pupil declines with age. Any eyepiece/telescope combo with a larger exit pupil than the eye's entrance pupil excludes some of the objective's light.

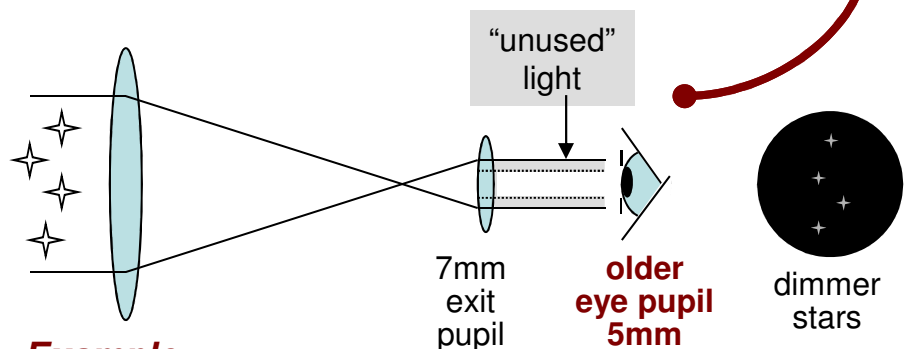
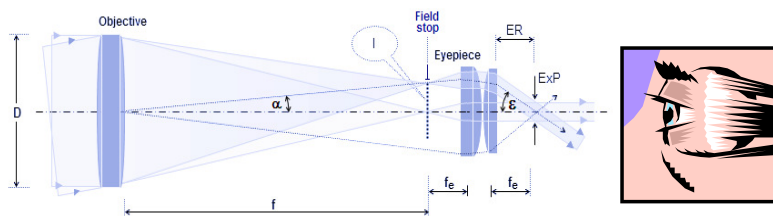
Eyepiece Exit Pupil & Eye Entrance Pupil



Eyepiece exit pupil \leq eye entrance pupil



All light collected by objective is captured by eye



Example

Objective $D = 100\text{mm}$, $f = 700\text{mm} \Rightarrow F7$
 Eyepiece $f_e = 50\text{mm}$ (typical 2" Plossl)
 Exit pupil = $50\text{mm} / F7 = 7.1\text{mm}$

Eyepiece exit pupil = f_e / F

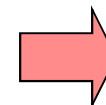
Example

Light from objective is reduced by ratio of pupil radii squared

$$r_{\text{eye}}^2 / r_{\text{eyepiece}}^2 = 51\%$$

Older observer would see light equivalent to a 70mm scope with that eyepiece

Eyepiece exit pupil \geq than eye entrance pupil





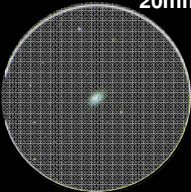

Smaller eye pupil excludes some light collected by objective

One can still use an eyepiece with a large exit pupil for its wide true field despite light loss.

Magnification and Field of View

Example scope is an Astro-Physics 155mm f7 EDFS

Useful magnification is constrained from above and below by physics, optical quality, mount steadiness, aperture, atmosphere and the eye's abilities

Comparison Example Plossl vs. Nagler	13 & 20 mm Plossls w/ 50° apparent FOV	13mm Nagler with 82° apparent field of view
Same focal length eyepieces yield same magnification regardless of AFOV	<p>Tunnel vision</p> <p>AP 155mm f7 w/ 13mm Plossl @ 85X</p>  <p>Same power 85X</p> <p>Small true field 0.55°</p>	<p>Ample FOV</p> <p>AP 155mm f7 w/ 13mm Nagler @ 85X</p>  <p>Large true field 0.9°</p>
Same true field of view from different AFOV eyepieces requires different magnifications	<p>Bright sky back-ground</p> <p>AP 155mm f7 w/ 20mm Plossl @ 55X</p>  <p>Same true FOV 0.9°</p> <p>Low magnification 55X</p>	<p>Dark sky back-ground</p> <p>AP 155mm f7 w/ 13mm Nagler @ 85X</p>  <p>High magnification 85X</p>

Point sources such as stars remain constant as magnification increases but extended objects grow dimmer; thus the sky dims.

Wide field eyepieces are heavier & costlier

Selected Eyepiece Types

Type	Inventor	Date	Elements	AFOV °	Notes
Huygens	Huygens	17 th century	2	~25	Poor quality, rarely used
Ramsden	Ramsden	18 th century	2	~35	Poor quality, rarely used
Kellner	Kellner	1850	3	40	Inexpensive, still used
Plossl	Plossl	1860	4	50	Widely used, top quality
Abbe/Ortho	Abbe	1880	4	45	Good planetary/lunar
Monocentric	Stenheil	1880	3	narrow	Good planetary/lunar - TMB
Konig	Konig	1915	3-4	55-70	Very few brands
Erfle	Erfle	< 1921	5-6	60-70	Poor edge performance
Kohler *	Zeiss	1960	11	120 (!)	Military binoculars
Nagler *†	Nagler	1979	6-7	82	Large, heavy, expensive
Panoptic†	Nagler	Early 1990s	6	68	Much better than Erfle
Radian *†	Nagler	1999	6-7	60	20mm eye relief for glasses
Ethos *†	Dellechiaie	2007	?	100	Large, heavy, expensive

* Negative (Barlow-like) lens group incorporated in optical path

† TeleVue-specific designs.

Obsolete	Infrequent	Inexpensive	Good quality	TeleVue
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— Sources: Various, including TeleVue, John Savard,
<http://www.quadibloc.com/science/opt04.htm>,
 and Brayebrook Observatory, Cambridgeshire, UK

Largest True Field and Exit Pupil

Type (TeleVue)	Focal Length fe (mm)	Barrel Diameter	AFOV (deg)	Field Stop* (mm)	Telescope Focal Ratio & Resulting Exit Pupil					
					F10	F8	F7	F6	F5	F4
Plossl	40	1.25"	43	27	4	5	5.7	6.7	8	10
Plossl	32	1.25"	50	27	3.2	4	4.6	5.3	6.4	8
Panoptic	24	1.25"	68	27	2.4	3	3.4	4	4.8	6
Plossl	55	2.00"	50	46	5.5	6.9	7.9	9.2	11	13.8
Panoptic	41	2.00"	68	46	4.1	5.1	5.9	6.8	8.2	10.2
Nagler	31	2.00"	82	42	3.1	3.9	4.2	5.2	6.2	7.8

$$\text{Exit Pupil (ExP)} = f_e / F$$

ExP less than 5mm (age 60)	5X/inch
ExP less than 7mm (age 25)	3.5X/inch
ExP greater than 7mm	<3.5X/inch

* 27mm is largest field stop that fits in a 1.25" barrel (32mm)
46mm is largest field stop that fits in a 2.00" barrel (51mm)

Maximum True Field Examples (degrees)

Eyepiece Barrel Diameter	AP 105 Traveler 600mm	AP 155 EDFS 1100mm	Starmaster 16 w/Paracorr 2000mm	Celestron C14 3900mm
1.25"	2.5	1.4	0.8	0.4
2.00"	4.3	2.4	1.3	0.7
North America Nebula 2.0°			Double Cluster 1.0°	Moon 0.5°

Eyepieces yielding exit pupils larger than the eye entrance pupil are still useable but some light from the telescope's objective will be lost

Bandpass and Attenuating Filters

Filters limit admitted light to a selected frequency range. They reduce the amount of transmitted light and thus object brightness. However, they increase object visibility by increasing contrast, e.g. by darkening the sky background more than the objects for which they are designed.

Nebula
Filters



Optimum Exit Pupil for Lumicon Nebula Filters
Exit pupil = eyepiece focal length / telescope f ratio

Filter Type	Deep Sky	UHC	OIII	H-Beta
Bandpass	90nm	22-26nm	10-12nm	8-10nm
Light-polluted sky	0.5-2mm	1-4mm	2-5mm	3-7mm
Dark sky	1-4mm	2-6mm	3-7mm	4-7mm



Color Filters (lunar & planetary)



White Light Solar Filters (Mylar)



Solar H-Alpha Telescopes and Filters

David Knisely Lumicon Filter Comparison *

Filter Performance Scoring	
5	Very Large Improvement over no filter
4	Large Improvement over no filter
3	Moderate Improvement over no filter
2	Slight Improvement over no filter
1	No improvement or slightly worse than no filter
0	Much worse than no filter

Scoring Summary (93 Objects - Sept 2006)		
Filter	Total	Average
UHC	330	3.55
OIII	297	3.19
Deep Sky	205	2.20
H-Beta	134	1.44

Ranking Summary				
Filter	Best Filter	2nd Best	Total	Notes
UHC	41	46	87	Best @ 3.5X to 10X per inch
OIII	33	23	56	Higher contrast but dimmer vs UHC
Deep Sky	7	3	10	Designed for light-polluted skies
H-Beta	14	2	16	Horsehead, California, Cocoon...

* Cloudy Nights: http://www.cloudynights.com/item.php?item_id=1520



Michael's Rules for Astronomy Gear

• Never buy anything larger than you can transport or heavier than you can lift – or that you need a mortgage to finance!



- With telescopes you get what you pay for, so buy the best you can afford – but only after enough research to be sure of your choice.
- If your budget is limited, plan on selling your old gear on Astromart when you upgrade – as you surely will if you stick with the hobby!



• It is a truth universally acknowledged, that possession of a new telescope must bring rain! [. . .with apologies to Jane Austen!]

- A really big Dob should come with an ark! (Or, in winter, a snow plow!)



• If you really like something, buy a lifetime supply; the maker will probably discontinue it three months before you need another one!

- However, if you do, the maker will soon thereafter introduce a new product that obsoletes it – and no one will want your lifetime supply of buggy whips!



• Pilots use checklists for a reason; so should those of us with porous memories! Otherwise you may run afoul of. . .

- Murphy's Law of Forgotten Gear: Whatever you leave at home will be needed that very night for the first time ever!
- Michael's Corollary: If you forget something, ask me; I probably have a spare in my accessory case! [see Lifetime Supply rule above!]



• **Forget Rule 1: Aperture wins – Buy an enormous Dob!**



Final Thoughts

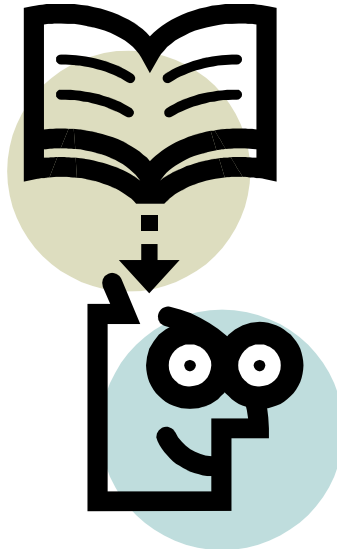
Every trip into the field is an opportunity to learn what works and what doesn't. The products described herein have stood the test of time and use for me – but many similar products would serve the same purpose effectively.



Don't economize – accessorize!!

Having “the right stuff” can enhance the viewing experience – and it prevents having an observing session end prematurely because of a mishap such as a blown fuse or dew condensation.

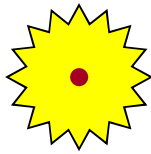
Questions & Answers



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[Reference: <http://www.copyright.gov/fls/fl102.html>, May 2009]



Never point a telescope at the sun
– unless it's a solar telescope, of course!!
...and don't look into the laser pointer either!!

