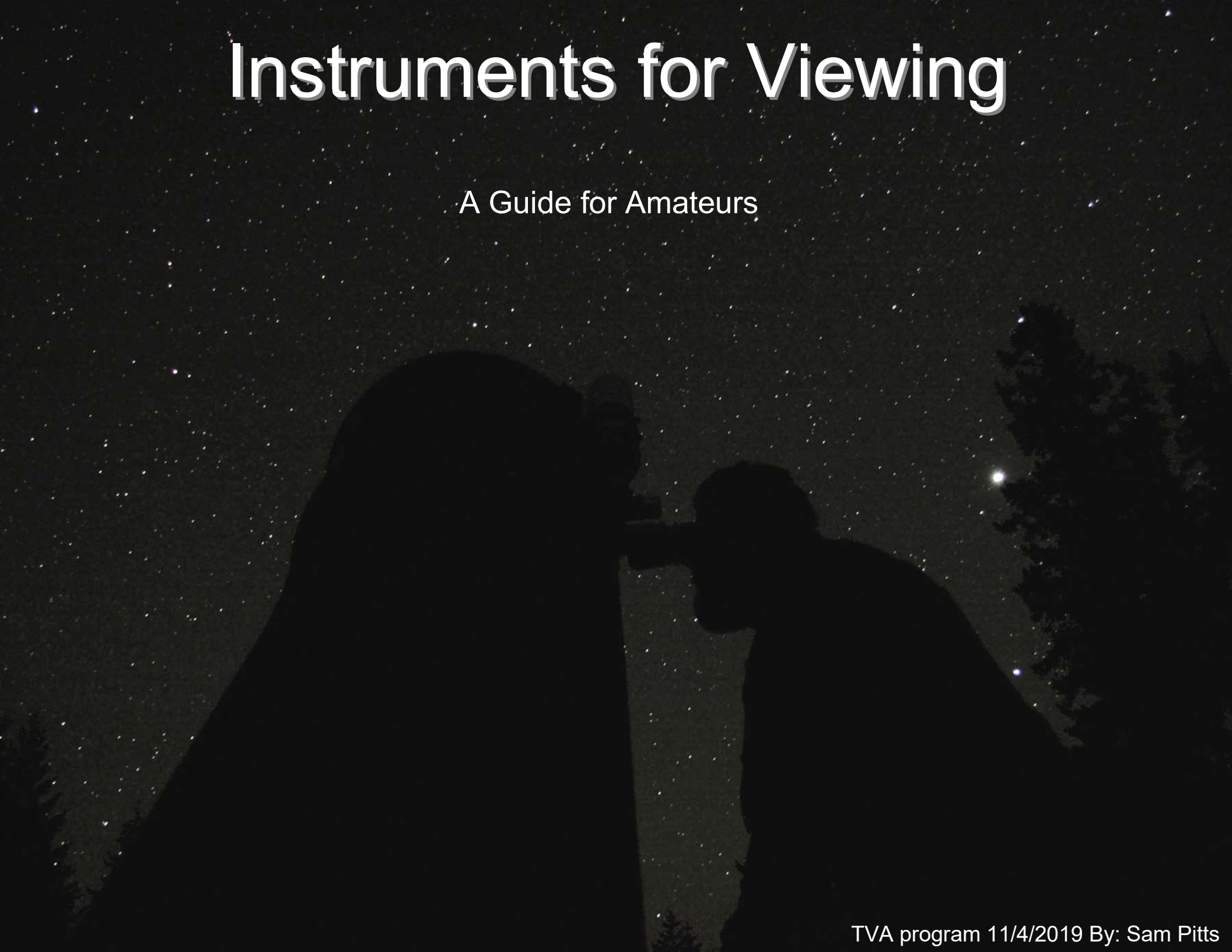
# Instruments for Viewing

A Guide for Amateurs



TVA program 11/4/2019 By: Sam Pitts

# Instruments for Viewing

**Education**

# Instruments for Viewing

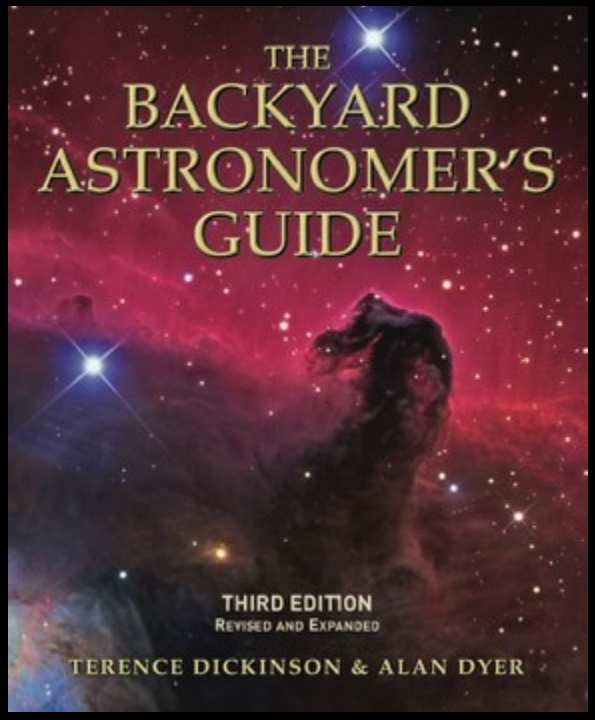
**Education**

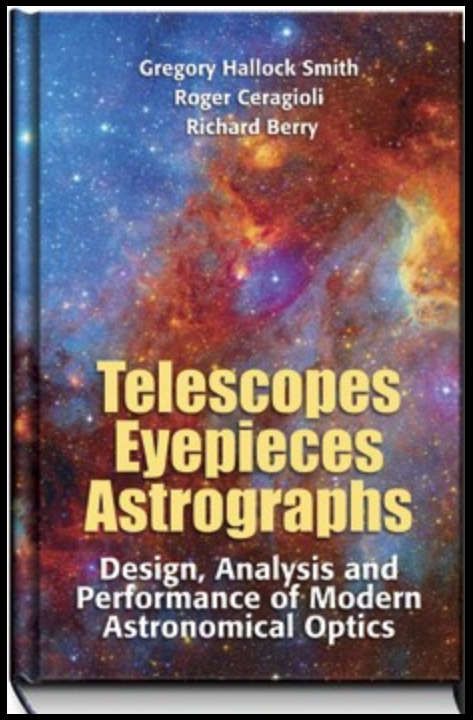
**Read The Instructions !**

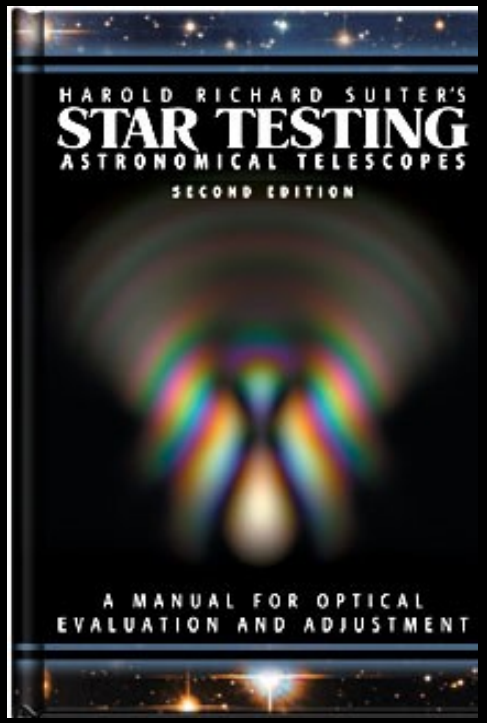
# Instruments for Viewing

**Education**

## Read The Instructions !

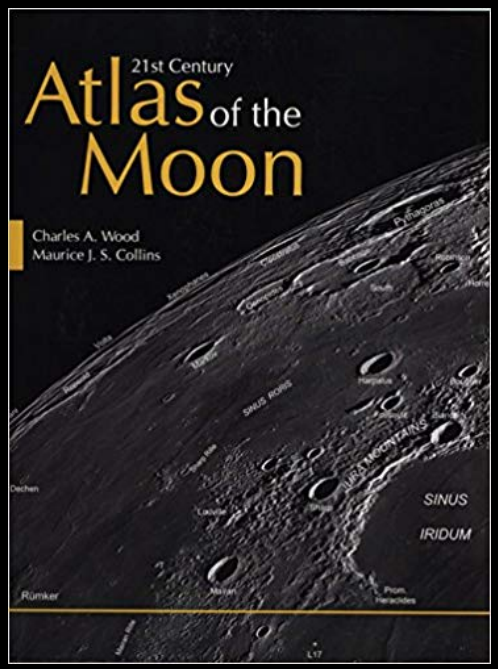


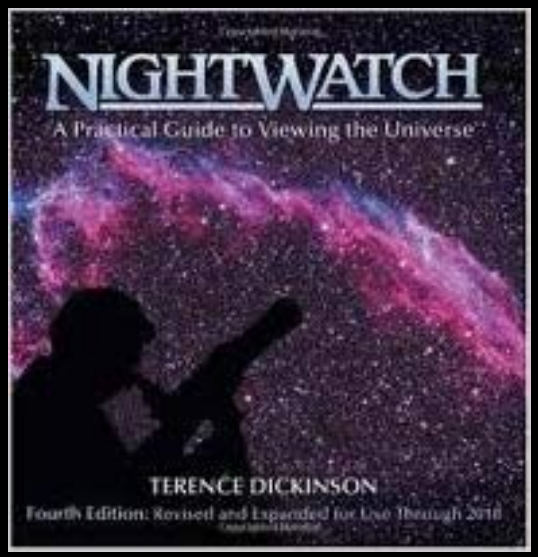



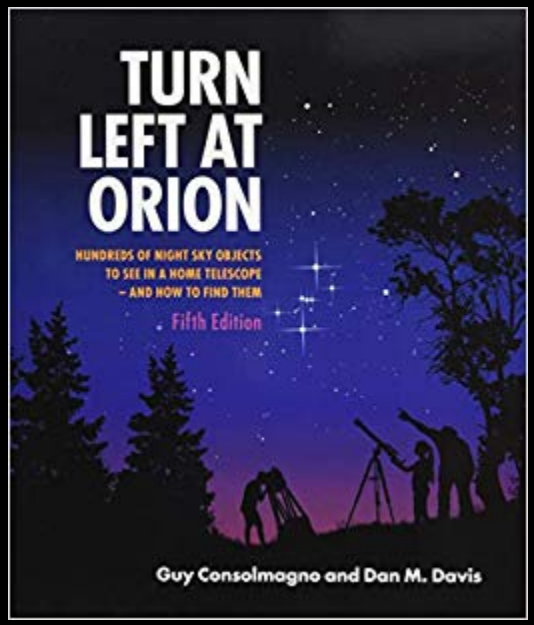



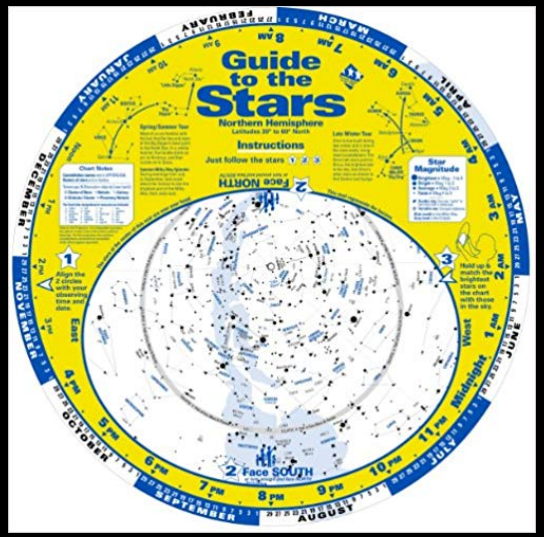
# Instruments for Viewing

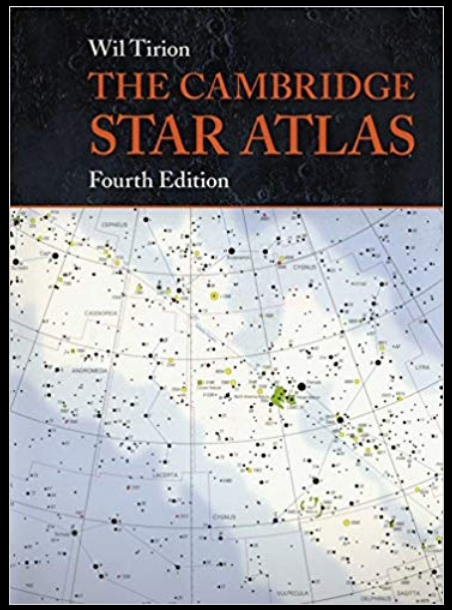
**Education**

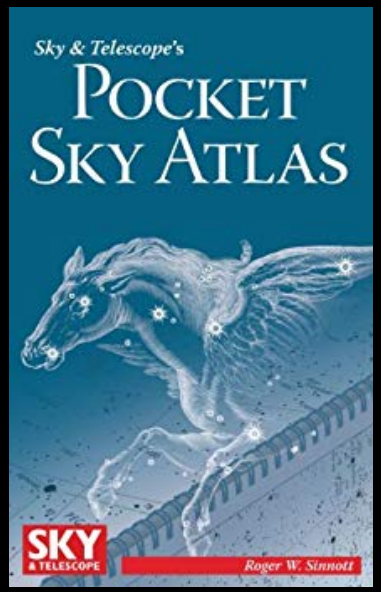


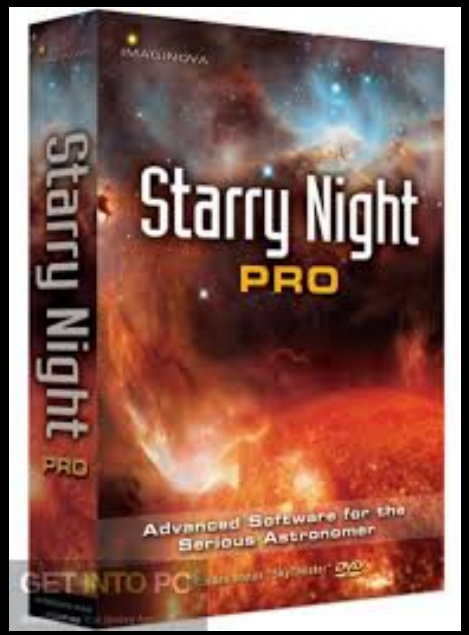



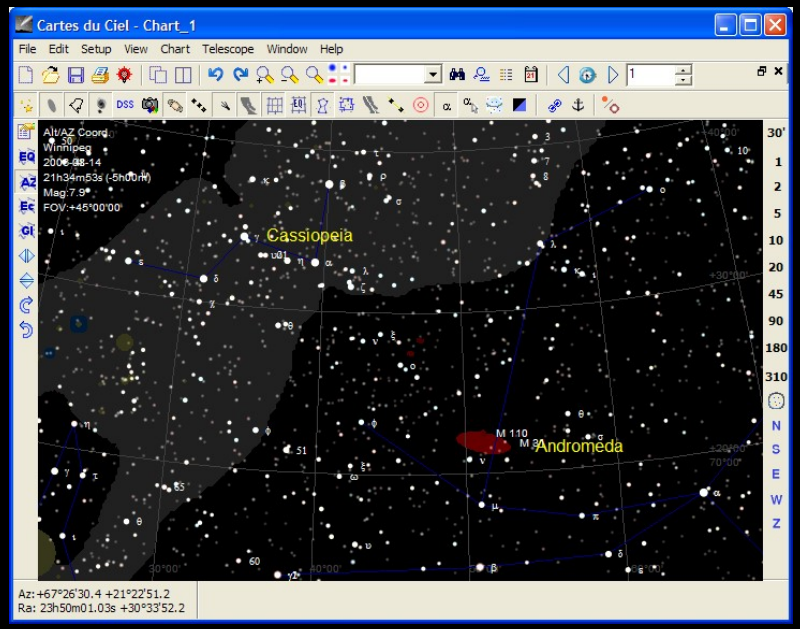



# Instruments for Viewing

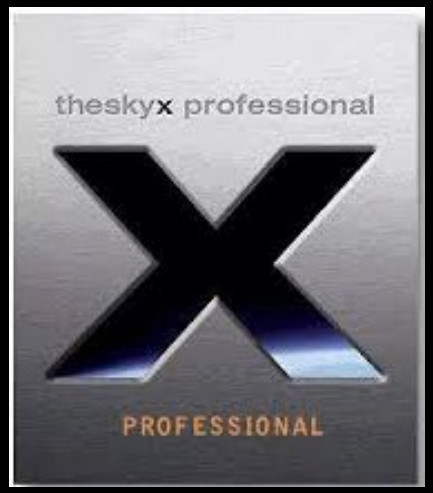
## Education





Cartes du Ciel


# Binoculars

Optical Quality

Weight

Price

Magnification

# Binoculars

Optical Quality

Weight

Price

Magnification

Objective-lens size

# Binoculars

Most Versatile & Essential Tool

Most Amateur Astronomers Buy a Telescope 1st

Naked eye – 3,000 stars

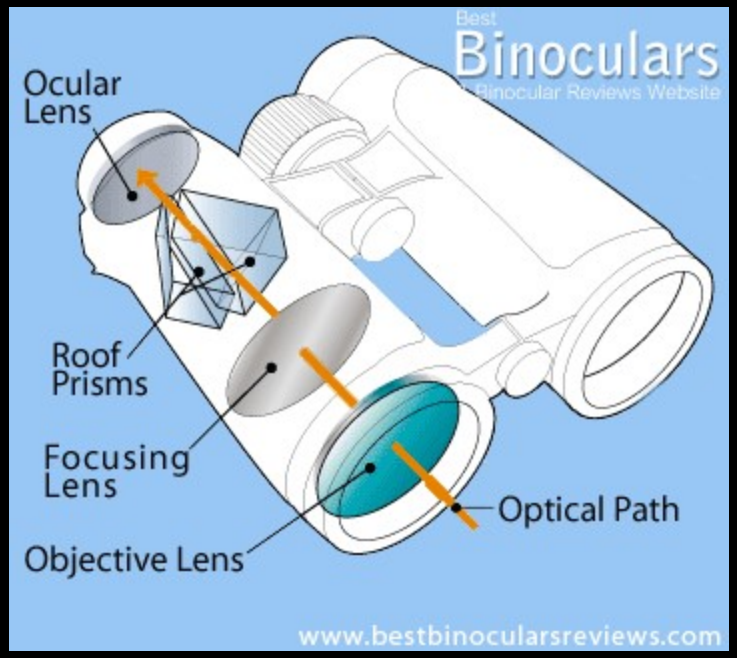
7 x 50 binoculars – 150,000 stars

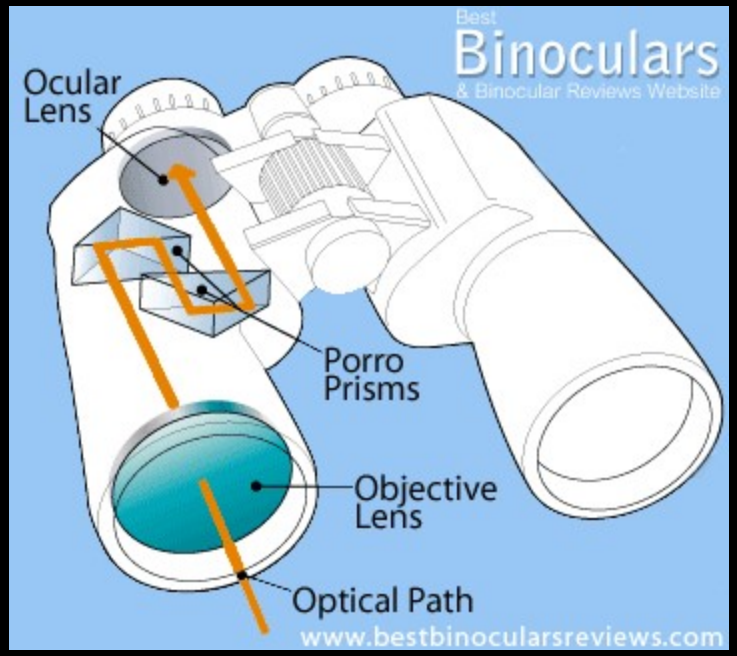
# Binoculars

Reasonable - Quality  for $100 → $150

Glass Multicoated Optics

Porro Prism cost less & offer equivalent performance



# Binoculars

What do the numbers mean ?

1st Number → Magnification

2nd Number → Diameter of Objective

FOV → number of feet that span at 1,000’

1° = 52.5’ span at 1,000’

7 x 50 = 7° - 8° FOV

10 x 50 = 5° - 6° FOV

# Binoculars

Exit Pupil

Light Cone exiting the Binocular or Telescope eyepiece

No larger than Dilated Pupil

Dark Adapted Pupil 5mm → 7mm

Bad News → After 30

1mm of loss every 10-15 years

Higher Magnification = smaller exit pupil

125mm telescope @ 175x = 0.7mm

# Binoculars

Best Size – Hand Held

7 x 50

10 x 50

12 x 50*


Nikon Aculon

7x50m, 10 x 50 & 12x50

$95 → $ 120

# Instruments for Viewing

## Telescopes

# Instruments for Viewing

**600x Refractor Telescope**
Model #T-6600
**$129.00**

Hobby Killer

**600x Refractor Telescope**
**Model #T-6600**

**Magnification:** 40-600x

**Objective Lens:** 60mm

**Focal Length:** 800mm

**Eyepiece:** SR4, H12.5, H20

**Barlow Lens:** 3x

**Erecting Lens:** 1.5x

**Finder Scope:** 5x Right-side up

**Diagonal Mirror:** 1.25”

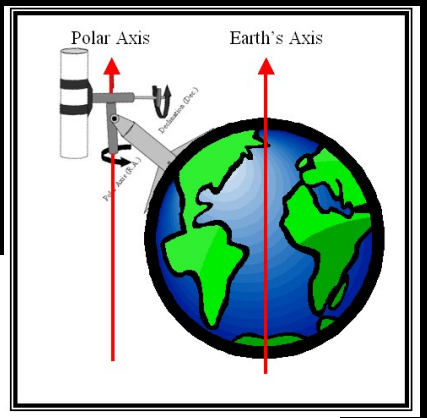
**Tripods:** 3 tier, collapsible aluminum tripod, center elevation control

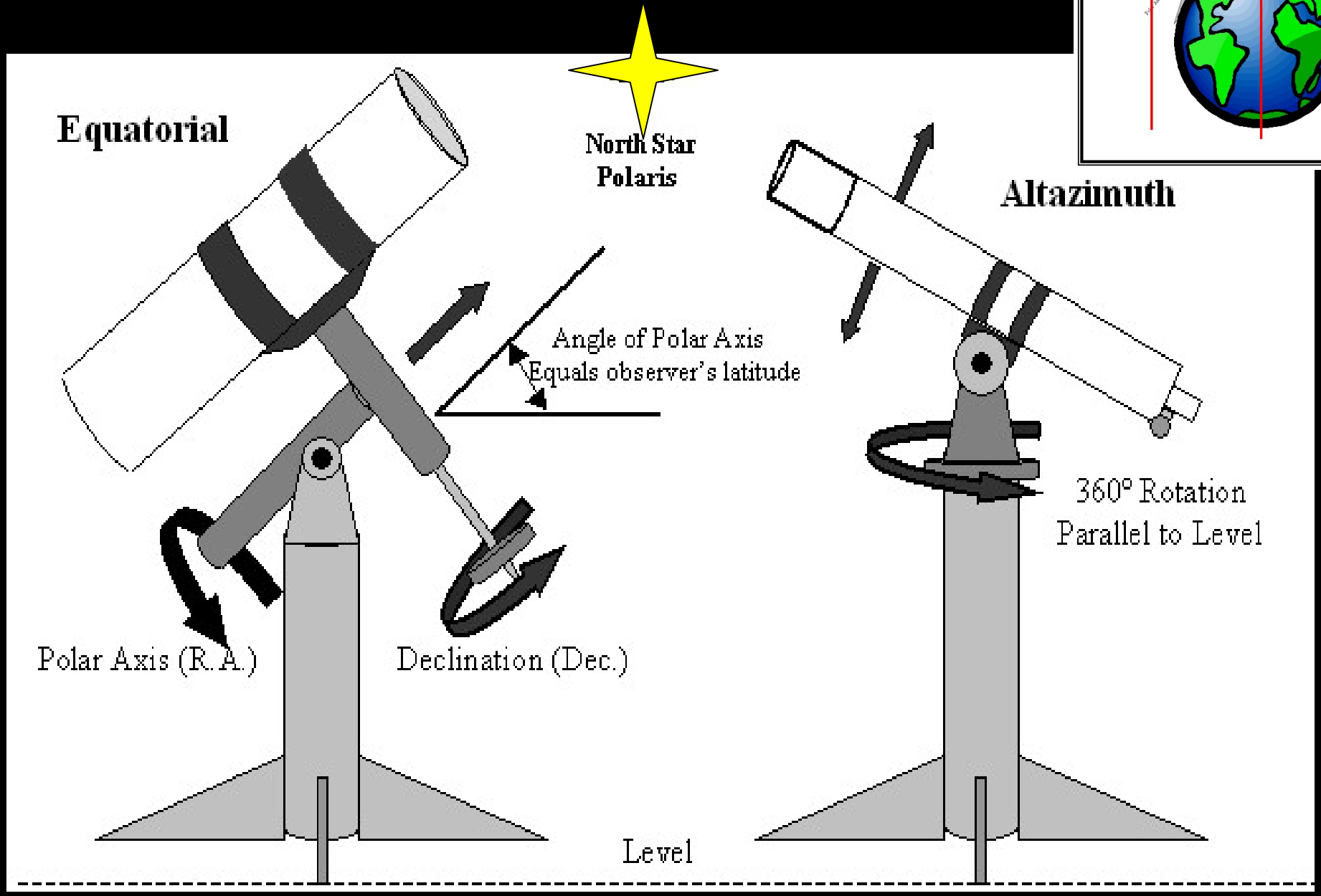
**Accessories:** CD-ROM **Weight:** 7 lbs.

# Telescopes

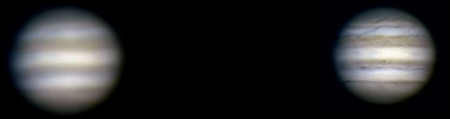
Hobby Killer

# Instruments for Viewing

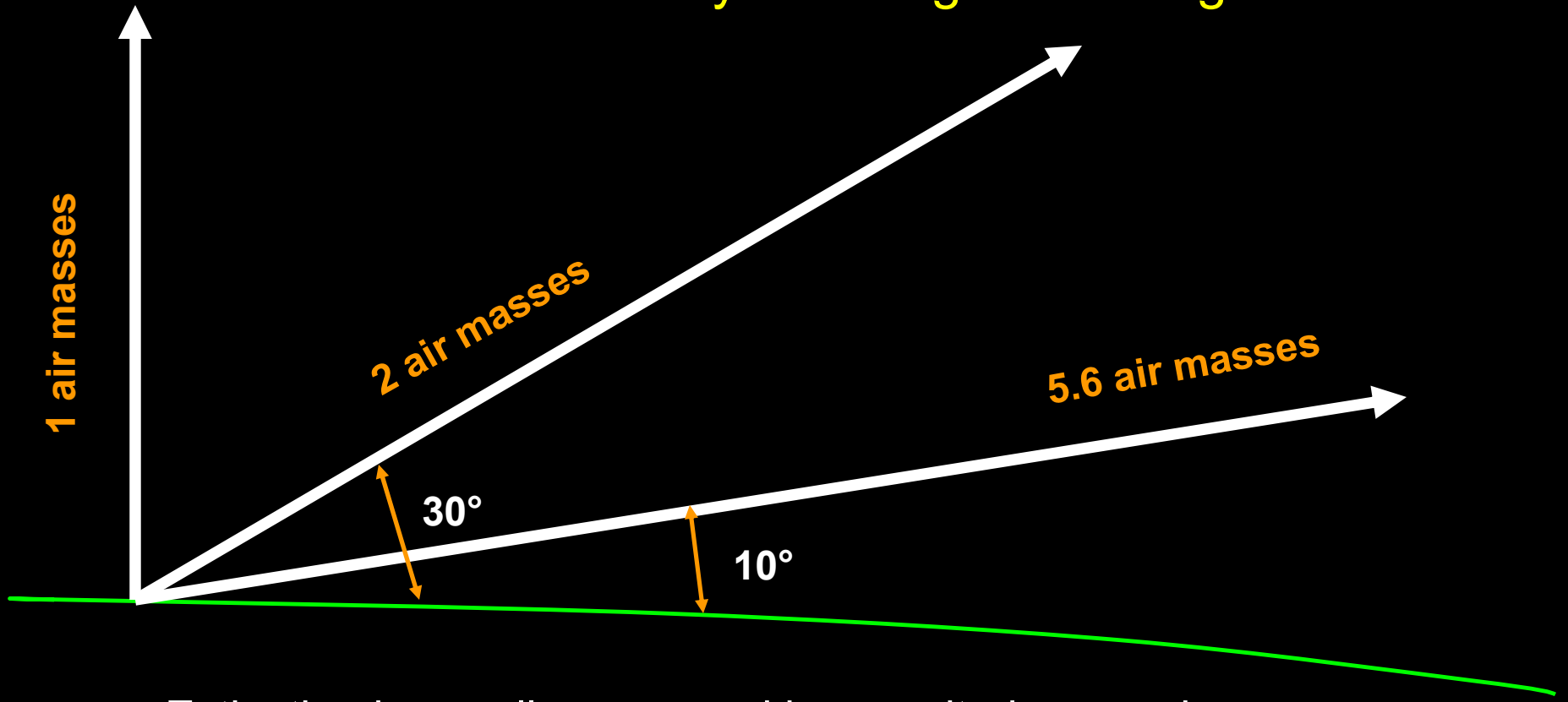


# Instruments for Viewing



Clear does not always mean good seeing



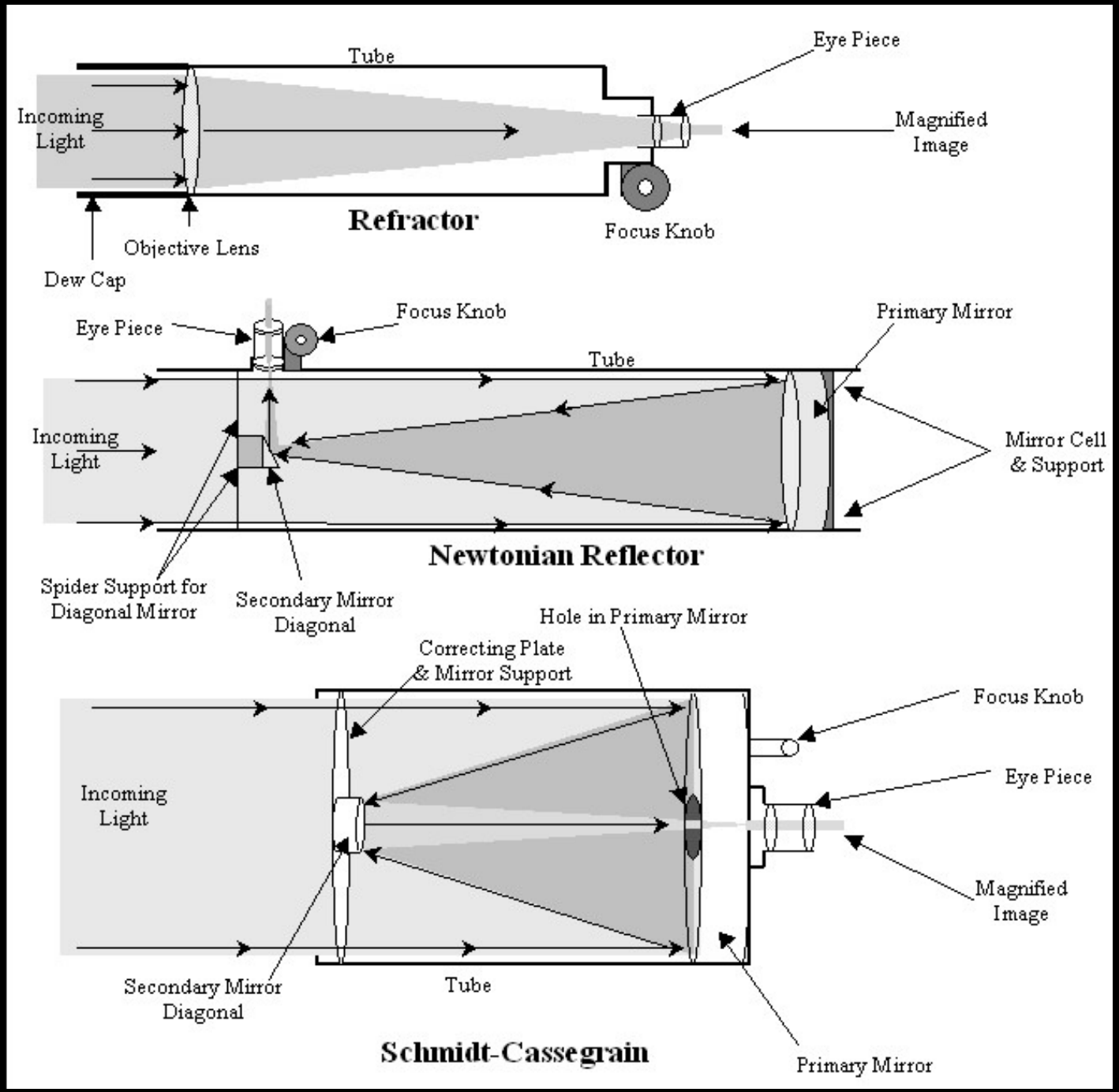

Extinction is usually measured in magnitudes per air mass

Extinction is 0.16 magnitudes per air mass  At zenith only 86% as Bright

Extinction at 30°  0.32 magnitude Fainter, only 74% as Bright

Extinction at 10°  0.90 magnitude Fainter, only 44% as Bright

# Instruments for Viewing



# Instruments for Viewing

**What about Quality**

**Beware of Advertising Misinformation**

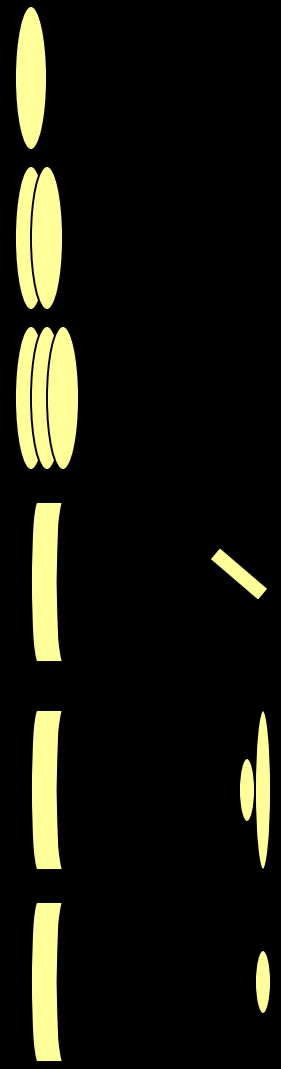
Star Test Your Scope

Buy from a Company That Tests Each Scope

Buy from Highly Respected Manufactures

# Instruments for Viewing

## Optics

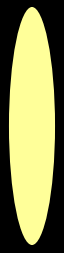


| | |
|---|---|
| Single Lens Refractor | Poor Correction simple design |
| Doublet Refractor | Good-Excellent Correction (ED) |
| Triplet Refractor | Excellent Correction (ED) (APO) |
| Newtonian Mirror | Excellent Correction |
| SCT -Corrector-Mirror-Mirror | Very Good Correction |
| Cassegrain Mirror-Mirror | Excellent Correction |

# Instruments for Viewing

## Optics

### Magnification



**Objective Diameter (“) X 50 = Highest Magnification**

6” Reflector x 50 = 300x

80mm (3.15”) x 50 = 160x

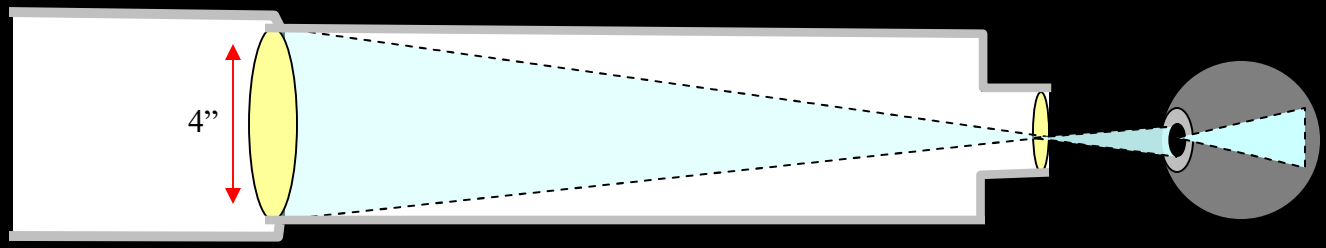
60mm (2.36”) x 50 = 120x

Some High Quality Optics can achieve 60-120x Diameter

# Instruments for Viewing

## Optics

How do we get Magnification ?




4” (102mm) F/7 Primary

Focal Ratio = Speed

102 mm X 7 = 714 mm FL

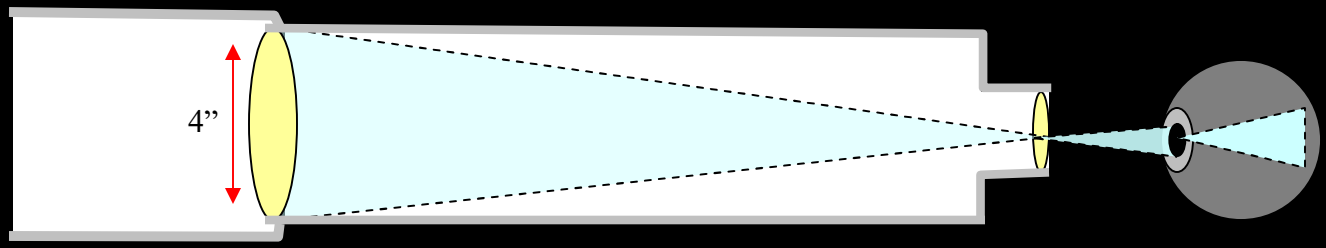
Eyepiece FL Divided into FL of OTA = Magnification

$$\frac{10\text{ mm}}{714\text{ mm}} = \mathbf{71.4x}$$

# Instruments for Viewing

## Optics

How do we get Magnification ?




4” (102mm) F/7 Primary

Focal Ratio = Speed

102 mm X 7 = 714 mm FL

Eyepiece FL Divided into FL of OTA = Magnification

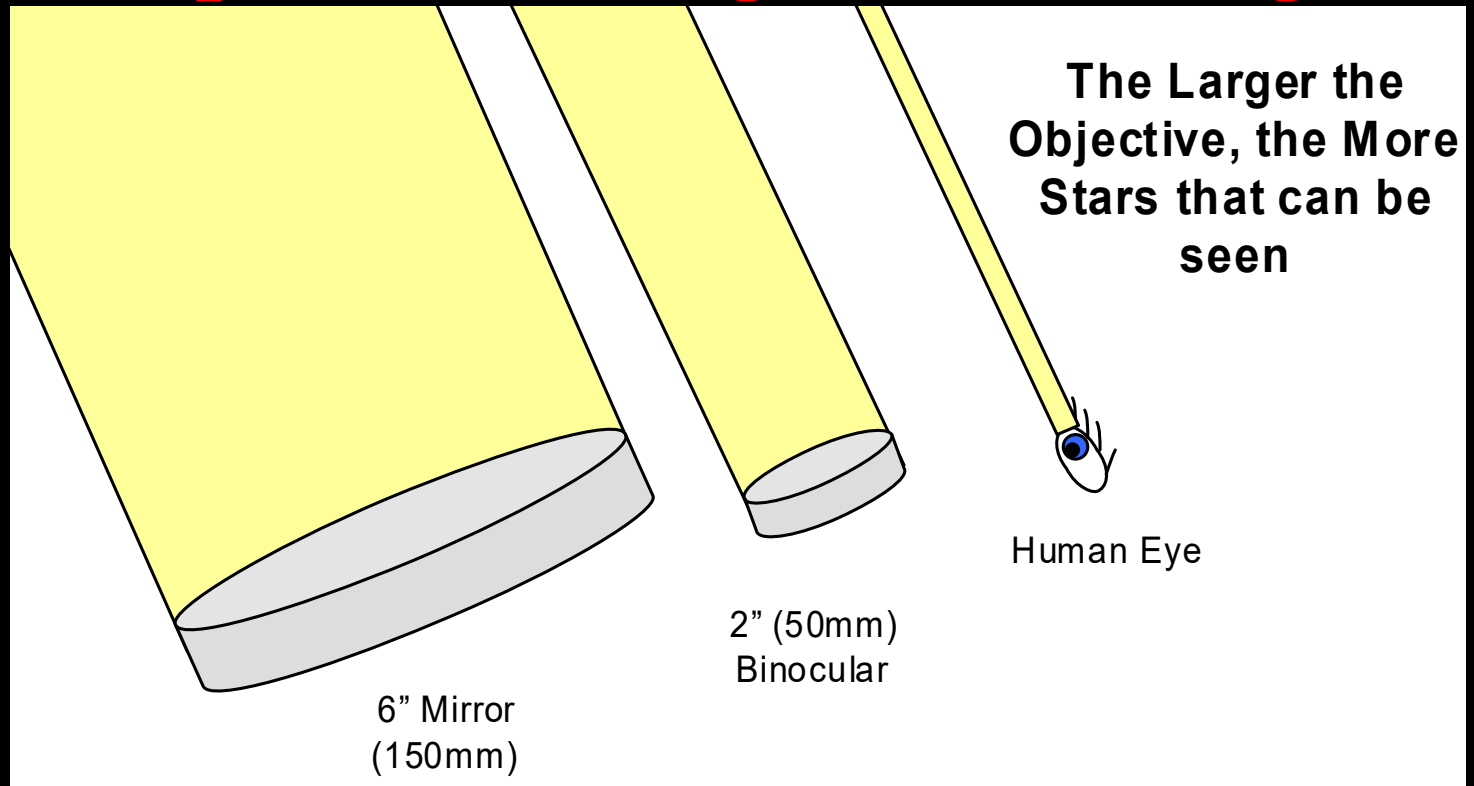
$$\frac{10\text{ mm}}{714\text{ mm}} = \mathbf{71.4x}$$

**Ignore Magnification**

# Instruments for Viewing

## Optics

## Aperture & Light-Gathering




**3” Lens Gathers Twice as much Light as a 2” Lens**

**6” Lens Gathers Four times as much Light as a 3”Lens**

**The Larger the Objective or Mirror The More Light is Gathered**

# Instruments for Viewing

## Optics

## Aperture & Light-Gathering

Telescopes should be rated by Aperture

Light Gathering = Surface Area

8” has 4x the Light Gathering of an 4”

Small → 2.5 – 5”

Moderate → 6 – 12”

Large → 14 – 25”

# Instruments for Viewing

## Optics

## Wavefront Error

Advertised as 1/8 → 1/20 wave

Measured in wavelengths of Green Light, how far the surface deviates from an ideal surface

What is the final Wavefront of light emerging from the telescope

Light reflected with surface accuracy of 1/16 wave has a Wavefront error of 1/8 wave. Each mirror produces a Wavefront error of 1/8 wave, results in a final error of ¼ wave, considered a minimum for perfect star images; Called Rayleigh criterion.

Manufactures almost never specify system Wavefront error

# Instruments for Viewing

Portability

# Instruments for Viewing


# Portability

# Telescopes

**Celestron advanced VX 8”**
**Newtonian $1,110**

**LX90-ACF 8-Inch (f/10)**
**$ 1699**

# Telescopes

Celestron advanced VX 8” Newtonian $1,110


8” Orion Classic Dobsonian $ 399.99

LX90-ACF 8-Inch (f/10) $ 1699

# Telescopes

**Orion CT80 EQ 80mm Compact f/5 Doublet Refracting Telescope $ 200**

**Sky-Watcher StarTravel 120 AZ3 f/5 Doublet Refracting Telescope Altazimuth mount $ 425**

# Telescopes

## The Traditional Refractor


Meade Adventure Scope 80mm $ 99.95


**Mead StarPro AZ™ 102mm Refracting Telescope $239**

# Telescopes

## The Traditional Refractor


LX85 Series Telescope - 5" Refractor
GoTo 30,000  $ 1,199.00

# Telescopes

## The Traditional Refractor


LX85 Series Telescope - 5" Refractor
GoTo 30,000  $ 1,199.00


# Telescopes

## The Wonderful Dobsonian

## Thanks John

John Dobson

*9/14/1915→1/15/2014*

# The Wonderful Dobsonian

# Telescopes

## The Wonderful Dobsonian

Orion 6” Sky Quest $ 299

Orion 8” Sky Quest $ 399

www.telescopes.com

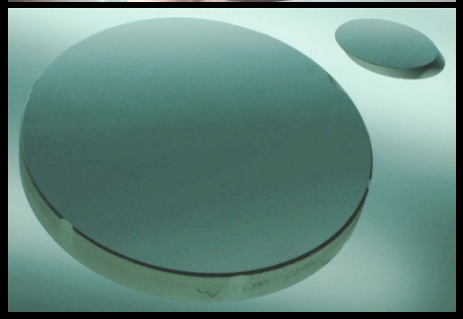
# Telescopes


www.telescopes.com

# Telescopes


SkyQuest XT10 PLUS Dobsonian Reflector Telescope Kit $ 849.00

10” GSO f/5 Primary optical grade BK-7 glass. 1/16 wave RMS $ 290



10” f/5 Primary Diffraction limited BK7 glass 1/16 wave RMS $ 349

10” f/5 Primary RMS of .032 and a Strehl Ratio of .96 or better at 633 nm for apertures up to 10" at f/5 or larger. Pyrex $ 850 (R.F. Royce)

Optic Wave Laboratories 10” 1.3” Pyrex f/5 $ 880 Quartz Call

Ostahowski Optics – Quartz call for prices 10” 1.2’ f/5 Quartz

# Telescopes


Meade LX70 Reflector 6” f/5 $ 639.95

# Telescopes


Meade LX70 Reflector 6” f/5 $ 639.95


Meade LX85 Reflector 8” f/5 GoTo
30,000 objects $ 699

# Telescopes


Meade LX85 Reflector 6” f/5 GoTo
30,000 objects $ 999


Meade LX85 Reflector 8” f/5 GoTo
30,000 objects $ 1,149

# Telescopes

## SCT Schmidt-Cassegrain


Celestron VX  6”F/10 $1,199  GoTo


Meade LX85  6” ACF F/10 $1,399 GoTo

# Telescopes

## SCT Schmidt-Cassegrain

Celestron VX 8” F/10 $1,939 GoTo

Meade LX85 8” ACF F/10 $1,799 GoTo

# Telescopes

## SCT Schmidt-Cassegrain


Celestron CPC 8” f/10  $1,999  GoTo


Meade 8” LX200-ACF f/10 $ 2,699 GoTo

# Telescopes

## SCT Schmidt-Cassegrain

Celestron VX 11” f/10  $2,579  GoTo


Meade 10” LX90-ACF f/10 $ 2,399 GoTo

# Telescopes

## SCT Schmidt-Cassegrain

Celestron GGX 1100 f/10  $4,199  GoTo

Meade 10” LX200-ACF f/10 $ 3,900GoTo

# Telescopes

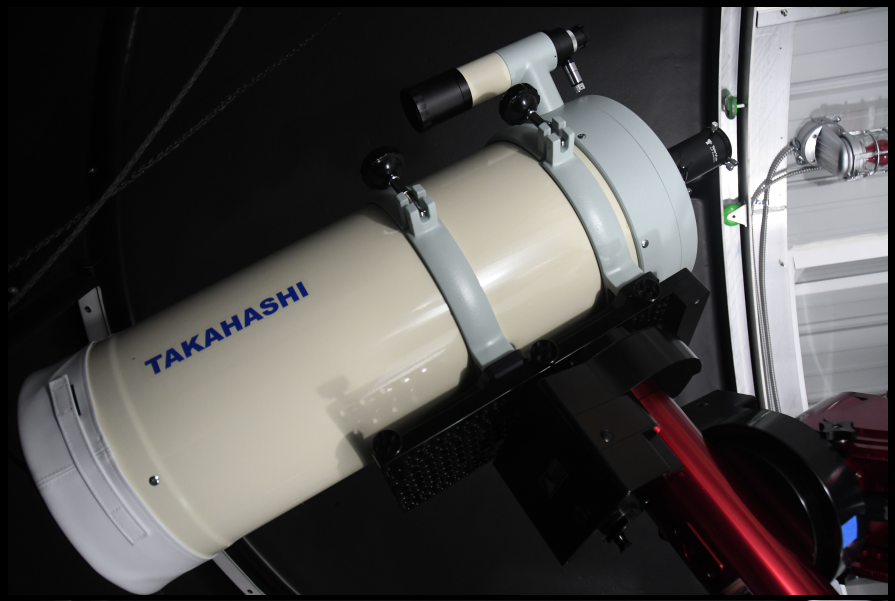
## Other Designs

TPO 8” f/8 Richie-Chretien $ 900

TPO 10” f/8 Richie-Chretien $ 2400

# Telescopes

## Other Designs






Takahashi Mewlon250mm CRS

$ 8,000 used Dall-Kirham

Takahashi 250mm RC $6,000 used

New model $17,000 Baker-Richie Chretien

# Telescopes

## Optical Advantage

| | Refractors | Reflectors | Catadioptrics |
|---|---|---|---|
| Optical Advantage | Unobstructed; usually superior optics | No chromatic aberrations, easy to make large size | No chromatic aberrations, good light gathering |
| Optical Disadvantage | Chromatic error | f/5 – coma, obstruction, multiple reflections | System light loss; central obstruction |
| Mechanical Advantage | Eyepiece location | Eyepiece location | Eyepiece location |
| Mechanical Disadvantage | Long tubes | Long tubes, counterweights | Balance fork mounts |
| Ease of Use Advantage | Very Portable | Comfortable Eyepiece | Great portability per inch |
| Ease of use Disadvantage | Large-tall tripod | Difficult to aim | None |
| Maintenance | Rare Collimation; closed tube; Dew | Less Dew; Collimation; exposed mirror | closed tube; Dew; secondary Collimation |
| Price Advantage | None | Low price per inch | Low cost-popularity sales |
| Price Disadvantage | Expensive per inch | None | Expensive vs. Newtonian |
| Advantages | <4” little thermal issue | Longer FL f/6+ excellent resolution, simplicity | Large range of accessories |
| Disadvantage | Long focal ratio; large lens need cool down | f/5 precisely collimated; optics need cooling; thermal effects | f/10-f/14 narrow FOV, closed tube cool-down |

# Telescopes

| Factors | Ach. Refractor 80-102mm f/10+ | APO Refractor 80-140mm f/7 | EQ Reflector 4” – 16” f/5-f/8 | Dobsonian 8 -25” f/4-f/5 | Schmidt-Cass. 4” -11” f/10 |
|---|---|---|---|---|---|
| Urban | Excellent | Excellent | Good | Poor-Good | Good - Excellent |
| Suburban | Excellent | Excellent | Excellent | Good - Excellent | Excellent |
| Rural | Good | Excellent | Excellent | Excellent | Excellent |
| Lunar | Good | Excellent | Good - Excellent | Good | Good |
| Deep | Poor | Fair | Good –Excellent | Excellent | Good - Excellent |
| General | Good | Good | Excellent | Good | Excellent |
| Photos | Poor | Excellent | Good-Excellent | Poor | Excellent |
| Optical Qual. | Fair-Good | Excellent | Good-Excellent | Fair-Good | Good |
| Mechanical | Poor | Excellent | Good | Good | Good |
| Light gathering | Poor | Fair-Good | Good - Excellent | Excellent | Good - Excellent |
| Portability | Excellent | Good - Excellent | Fair | Good | Good - Excellent |
| Setup | Fair-Good | Fair-Good | Fair-Good | Good-Excellent | Excellent |
| Ease of Use | Good | Good | Fair | Good | Excellent |
| Maintenance | Excellent | Excellent | Fair | Fair | Good |
| Storage | Small | Average-Large | Average-Large | Large | Average-Large |
| Delivery | Excellent | Poor –Good* | Good | Good - Excellent | Excellent |
| Price per Inch | Average | Very-High | Average | Low | Average |
| Resale | Poor | Excellent | Good | Fair | Good |

# Instruments for Viewing

Accessories

Focuser

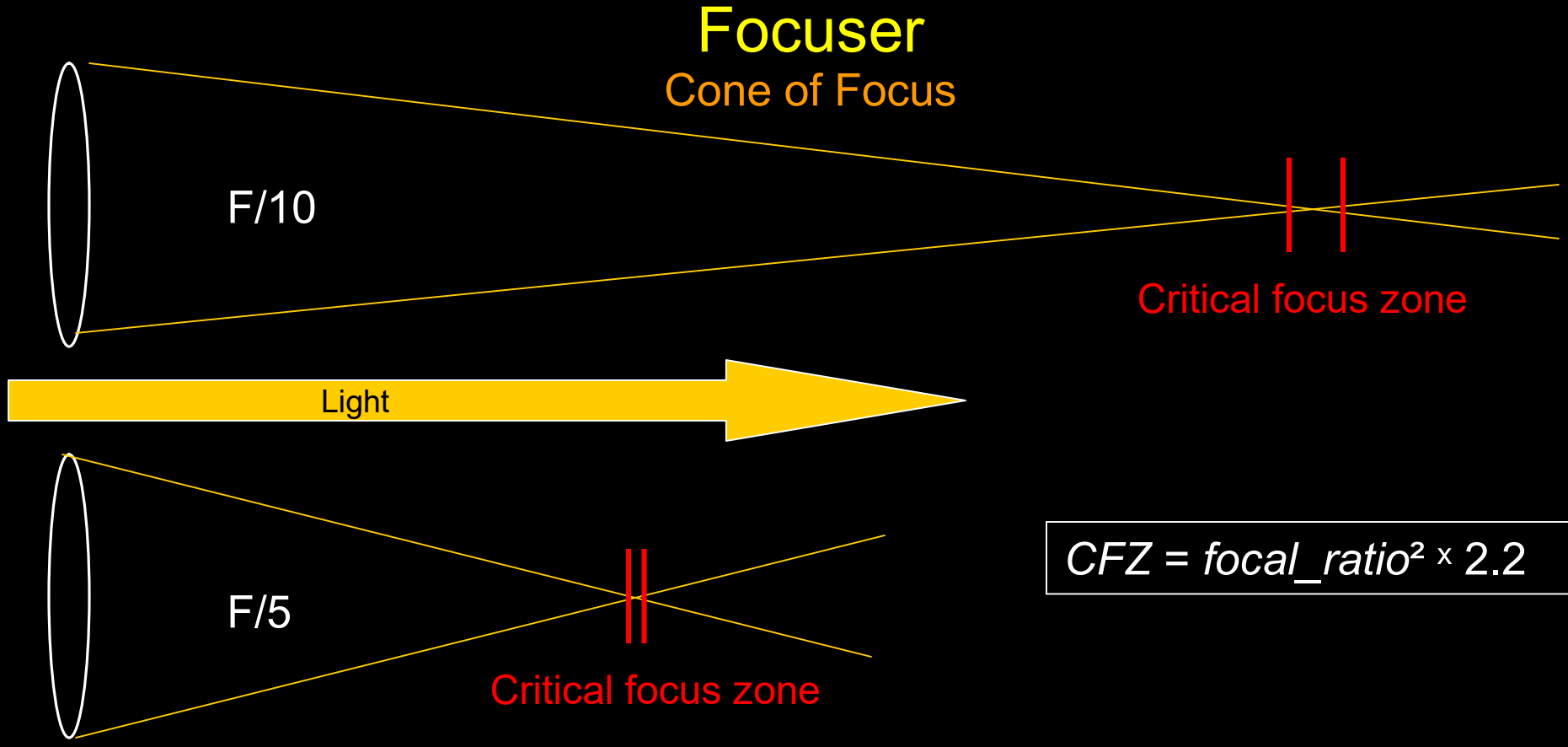
Diagonal

Eyepieces

Finders

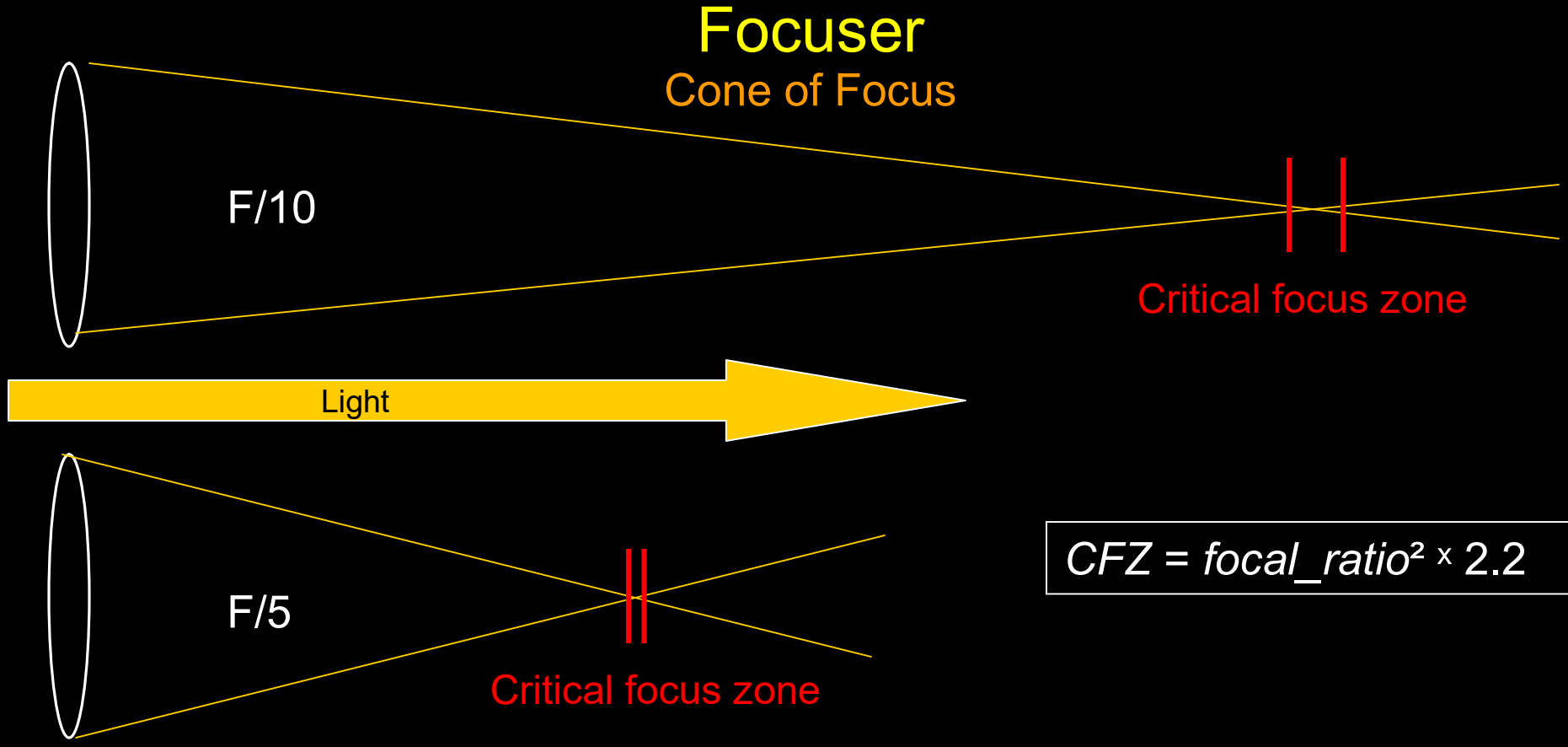
Maintenance

# Instruments for Viewing




$CFZ = focal\_ratio^2 \times 2.2$

# Instruments for Viewing

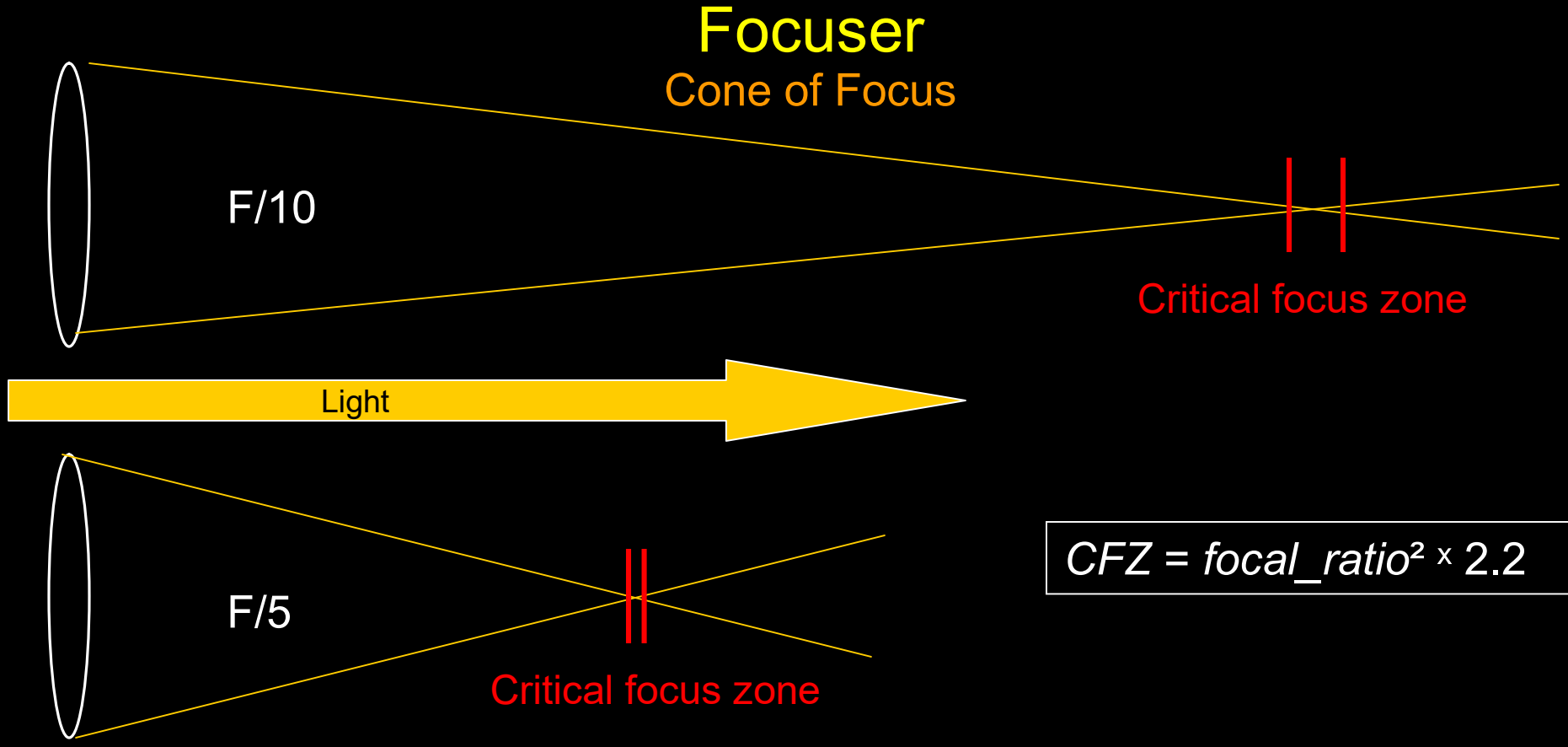



$CFZ = focal\_ratio^2 \times 2.2$

C11 f/10

CFZ = $10^2 \times 2.2$ = 220 microns (0.22 mm) 0.0086”

# Instruments for Viewing




$CFZ = focal\_ratio^2 \times 2.2$

C11 f/10

CFZ = $10^2 \times 2.2$ = 220 microns (0.22 mm) 0.0086”

TMB 80 f/4.8

CFZ = $4.8^2 \times 2.2$ = 50.7 microns (0.05 mm) 0.00197”

# Instruments for Viewing

## Focuser


TPO Dual Speed $128 SCT


TPO Dual Speed $156 Refractor

# Instruments for Viewing

## Focuser

Orion Low Profile Hybrid Dual Speed Focuser
$ 249

# Instruments for Viewing

## Focuser


# Instruments for Viewing

## Focuser


Feathertouch Dual Speed 2” $ 535

# Instruments for Viewing

## Diagonal


Meade 2" Enhanced Dielectric Diagonal
$ 149


William Optics Dura Bright 2" Dielectric Diagonal - Carbon Fiber $ 139


Astro-Physics Maxbright
2" Mirror Diagonal
$ 320

# Instruments for Viewing

## Eyepiece

**Get Good Eyepieces (Oculars)**

Eye Relief : 15mm → 20mm

Barrel Size: 1 ¼” → 2”

Fully Multi-Coated

Eye Piece set 1 ¼” → Plössl : 32mm; 26mm, 20mm + 2x Barlow

Eye Piece set 2” → Plossl : 40mm; 32mm, 22mm, 18mm + 2x Barlow

Wide Field

# Instruments for Viewing

## Eyepiece

## Get Good Eyepieces

| Eye Piece Designs | Barrel | Apparent Size | Deep Sky Field | Planetary Lunar | Average Cost | General Recommendation |
|---|---|---|---|---|---|---|
| Kellner(1) | 1 ¼” | 35º- 40º | OK | OK | $ 40.00 | Fair |
| Orthoscopic | 1 ¼” | 30º- 50º | OK | Excellent | 90.00 | Very Good |
| Plössl (4+ elements) | 1 ¼” | 45º- 55º | Very Good | Excellent | 120.00 | Very Good + |
| Super & Ultra Wide | 1 ¼”-2” | 60º- 84º | Excellent | Excellent | 180.00+ | Excellent |
| Erfle | 1 ¼” | 60º | Very Good | Fair | 100.00 | Good |
| Panoptic | 1 ¼” | 68º | Excellent | Excellent | 280.00+ | Excellent |
| Nagler | 1 ¼”-2” | 80º- 84º | Excellent | Excellent | 300.00+ | Excellent + |
| Celestron Luminos | 1 ¼”-2” | 80º- 84º | Excellent | Excellent | 250.00+ | Excellent |
| Meade 5000 | 1 ¼”-2” | 100º | Excellent | Excellent | 250.00+ | Excellent |

**Avoid most .965” Eyepieces**

**FOV 2000mm FL 40mm EP= 50x**

**Plössl 55° divide by Magnification (50x) = 1.1° FOV**

# Instruments for Viewing


Ethos : $615 - $ 895

Delos : $315 - $ 370

Nagler : $330 - $ 655

Panoptic : $270 - $ 550

Plössl : $100 - $ 255

# Instruments for Viewing

## Eyepiece


Explore Scientific
9mm 120° 2” Argon Purged
Waterproof $ 1,000
(13mm)


Explore Scientific
100° Waterproof
$ 250 - $1200


Explore Scientific
82° Waterproof
$ 100 - $ 250

# Instruments for Viewing

## Eyepiece


Meade Series 5000
Ultra Wide 82°
$ 130 - $300


Meade Series 5000
XWA 100°
$ 300 - $500


Meade 4000 Super
Plössl 44°
$ 30 - $ 80

# Instruments for Viewing

## Finders


**Telrad Telescope Reflex Finder with Mounting Base and Selectable Red / Green Illumination $ 65**


**Reflex Telescope Finder Sight $ 40**

# Instruments for Viewing

## Finders


**Right Angle Finder Scope $ 80**

# Instruments for Viewing

## Finders


**Straight Viewing Erect Image**
**$ 190**


**Baader Planetarium Vario Erect Image Finder Scope $ 359**

# Instruments for Viewing

## Finders


**Dovetail plate and Orion Scope Not Included.**

**Finder & Guide Scope**

# Instruments for Viewing

## Maintenance

**Collimation**

Newtonians →Often

Schmidt-Cassegrain → Sometimes

Refractors → Rare

Be sure to support the Mirror !

# Instruments for Viewing

## Collimation

Collimation eyepiece is a metal tube with crosshairs in it  Looking through it you see the crosshairs overlaying the telescope optics, allowing you to determine the alignment of the mirrors.

A laser collimator also fits into the focuser like an eyepiece.  It projects a red laser beam, placing a dot onto the primary mirror which is reflected onto the secondary mirror then back onto the collimator (when everything is properly aligned).

https://starizona.com/tutorial/collimating-a-newtonian/

# Instruments for Viewing

## Collimation

## 4. Advanced Techniques

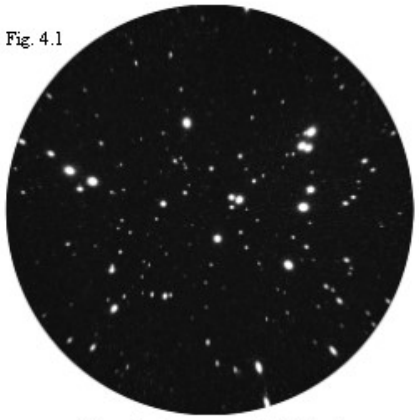
### Collimation

Well-made telescope should last a lifetime, there are few parts that should ever wear out. The Coatings on some mirrors may need to be redone after fifteen to twenty or more years of use. The hardest thing on a telescope is moving it over rough or bumpy roads. Many telescopes, especially reflectors, Schmidt-Cassegrains and Newtonians will not remain collimated.

Even a brand new scope may suffer from poor Collimation, as a result of poor shipping practices. Many discussions regarding how good one scope is over another type, model or brand, can be a result of poor Collimation and not bad optics.

To obtain the best performance from any telescope, all of the lenses and mirrors must be centered and angled properly. When this is not so, stars become flared and look like small comets. Don't confuse this with fast optical systems of F/6-F/3. These will show distorted stars near the edge of the field of view (Fig 4.1). This is inherent in very fast optical mirrors used in Newtonians and Schmidt-Cassegrains. Fast quality Fluorite Refractors will not suffer from this.

Fig. 4.1



Example of an average F/4 Reflector
Note how the Stars start to flair near the edges
The center of the field is still sharp & Clear

The quickest way to determine if you scope needs collimating is to focus on a star and turn the focuser in a direction, which will cause the star to form a large disc, which should be perfectly symmetrical. This should be true on either side of focus. Refractors and Maksutovs are collimated at the factory and should never need to be adjusted. Should you have one of these that does not focus sharply or stars are flared, return it to the manufacture for repair.

Schmidt-Cassegrains are the easiest to Collimate, make sure the scope has cooled down for awhile. Pick a fairly bright star near the zenith and focus on it with 25mm eyepiece without a diagonal. Turn the focus knob until the star is a large circle, similar to images in Figure 4.2

The center shadow, is the shadow from your secondary mirror and should be perfectly round and dead center with concentric rings emanating out. All of these rings should be perfect circles this is perfect Collimation. Should the center shadow be flared to

Good Collimation

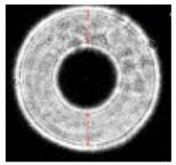


Fig. 4.2

Poor Collimation

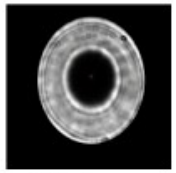


Fig. 4.3

Bad Collimation

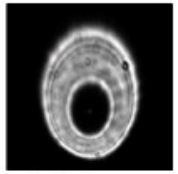


Fig. 4.4



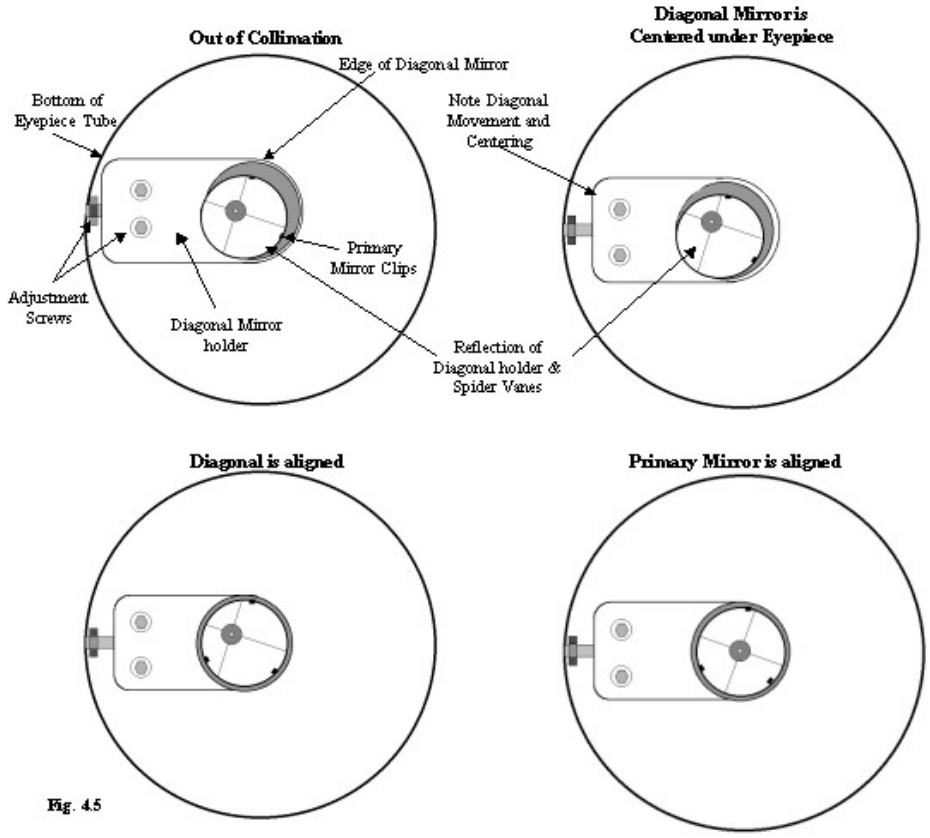



Fig. 4.5

### Cleaning Optics

Dust on the corrector plate (Lens) or main objective lens or mirror will have little or no effect on your observing. I may clean my corrector plate once every three to five years. Don't worry about a little dust.

Should you really feel the need to clean your corrector plate or lens do not use commercial lens cleaners. Mix 90%-100% isopropyl (rubbing) alcohol with distilled water in a 50/50 to 60/40 solution. Alcohol should make up 50-60% of the solution. Then add a few drops of dishwashing liquid (none perfumed).

Mist the area to be cleaned and use pure cotton balls or lint free lens cleaning tissue. Dapple or matte the surface to get the solution up. Do not wipe, but dapple it off. Try not to polish the surface at all. Be very careful, you can cause hundreds of dollars worth of damage.

Best way to prevent the need for cleaning is not to let the dust build into mud by mixing with dew. Use canned air, made for cleaning computers, to blow the dust off. Make sure to hold the can at the right angle or the accelerent can come out and cause another cleaning headache. Keep an eye on dew use a dew heater. Avoid over cleaning!

# Instruments for Viewing

## Collimation




Bob's Knobs

# Instruments for Viewing

## Maintenance

**Cleaning**

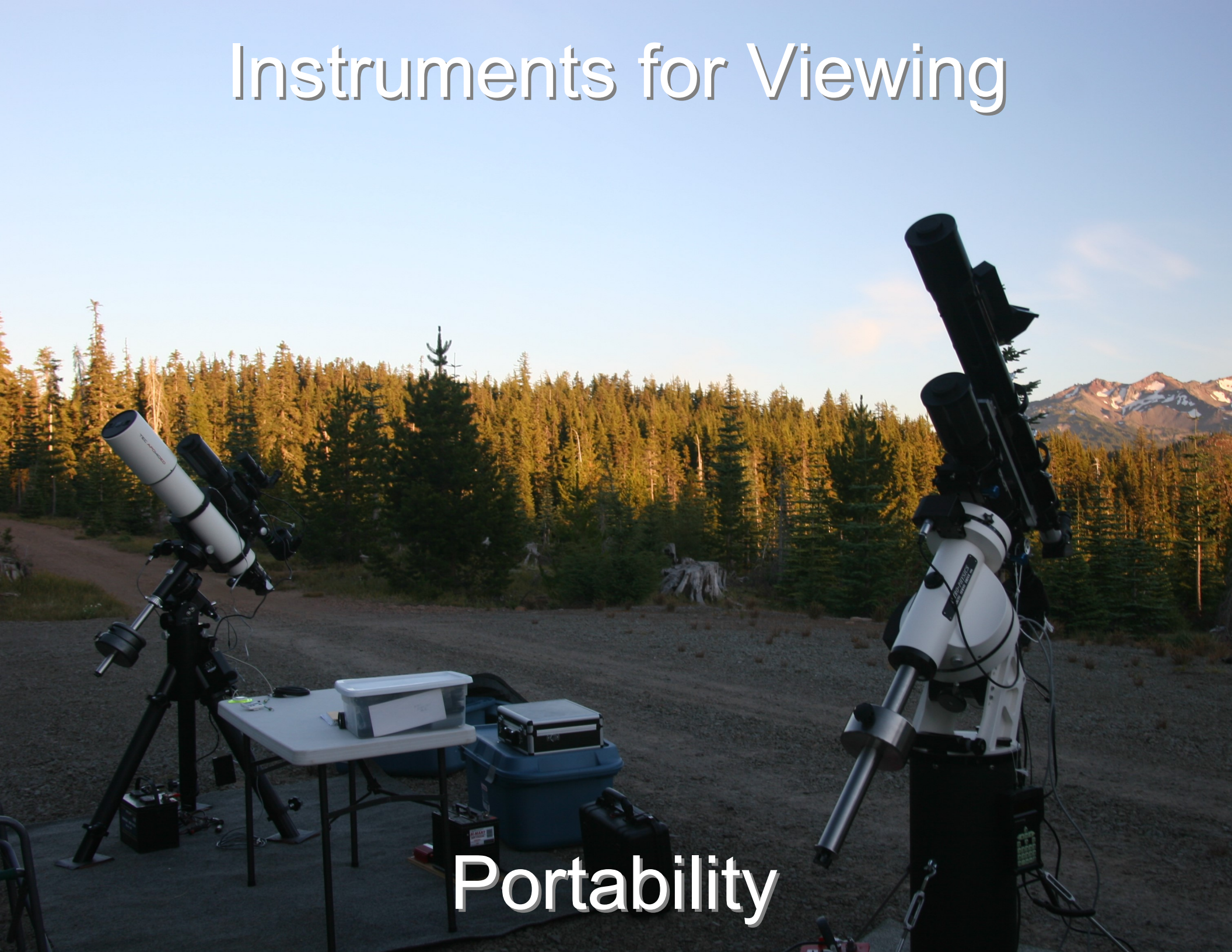
Don’t clean optics unless its Absolutely Necessary

A little dust won’t interfere with views or imaging

Stand 20’ away and if you see dust then consider cleaning

Follow manufactures cleaning recommendations

# Instruments for Viewing



Portability

# Instruments for Viewing

Clear Steady Nights