All about Eyepieces

Eyepiece Intro

Magnifying lenses that enlarge images formed by telescope.

1. **An Eyepiece** is nothing more than a magnifying lens/glass but usually consists of multiple lenses in a few groups instead of a single lens element (in order to correct for optical "defects").
2. **Eyepieces are CALLED EYEPIECES and NOT lenses** in the astronomical community.
3. **Eyepieces of different focal lengths are used to change the magnification of the telescope.** So, several eyepieces, each with a different focal length, are used in a telescope to provide a range of magnifications, from low power to high power.
4. **The Focal Length** of eyepieces is **always** **expressed in millimeters and is always engraved on the eyepiece**. Although focal lengths vary from about 3mm to 55mm, many telescope users have a few to several eyepieces in the range from 3mm to 35mm.
5. **Smaller/shorter focal lengths provide the *higher* magnifications—see the next slide to calculate magnification.**
6. **Cost — varies from about $10 each to over $850 each.**

Remember, there are 25.4 millimeters in 1 inch.

All lengths are in **millimeters**

Calculating Magnification

Telescope Focal Length ÷ Eyepiece Focal Length

If, your telescope has a focal length of 540mm and your eyepieces have focal lengths of 6, 15 and 20mm, what are your magnifications?

6mm ➡ **540 ÷ 6 = 90x**
15mm ➡ **540 ÷ 15 = 36x**
20mm ➡ **540 ÷ 20 = 27x**

1 inch = 25.4mm

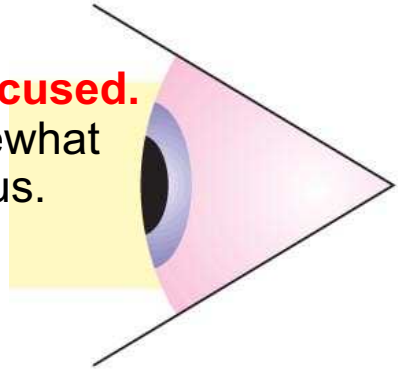
Magnification Woes

1. Magnification is not of supreme importance because…
2. 40x to 150x is used most which any 3-inch diameter telescope can achieve.
3. Around 100x to 250x is used on the planets, as long as the “seeing” is steady. 4- to 6-inch scopes can easily achieve these magnifications.
4. 400x is about the maximum for *any* telescope and can only be achieved with the larger scopes (8-inches plus on nights when the atmosphere is steady) and is usually reserved for the Moon and Planets.
5. Larger diameter telescopes are better (8 to 30 inches), not for magnification, but to collect more light in order to make fainter objects brighter, like nebulae and galaxies.

Individual Focusing

Eyes are optical systems and vary from person to person so everyone needs to focus/refocus the eyepiece to obtain sharp imagery. Sometimes it is just a little and other times it can be more depending on who viewed before you.

Stars should look like pinpoints when the eyepiece is focused.
Depending on the steadiness of the sky, planets might be somewhat soft around the edge but it will be apparent when in focus.



Sweet Spot

Each eyepiece has a sweet spot, meaning a place where the eye fully sees the image. It can take a little effort finding the sweet spot—by moving the head slightly sideways, so the eye is centered and/or changing the distance from the eye lens.

If you don't find the sweet spot you may see nothing or just part of the image. Remember, with many short focal length eyepieces, you may have to cram your eye into the eye lens.

General Characteristics

Common Themes with Eyepieces

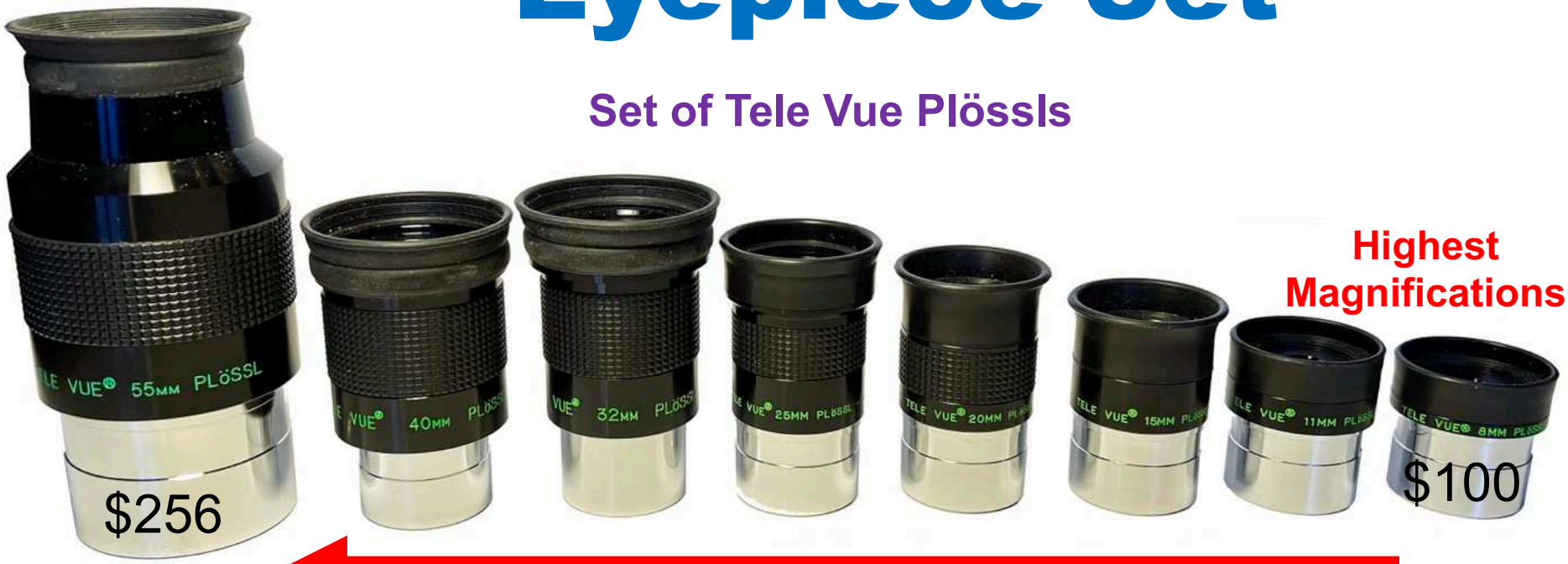
1. **Barrel Diameters** are **1.25 inches or 2 inches**. All telescopes accept 1.25 inch eyepieces. 2-inch diameter eyepieces are not normally needed and are big and heavy—they are used to get the biggest Field of View with longer focal lengths. I have both but 99.9% of the time I use 1.25 inch eyepieces—small, lightweight and easily fit into pockets.
2. **Eyepiece Sets.** Eyepieces are normally designed/manufactured in sets/families that span a range of focal lengths and have similar optical and mechanical designs. Usually, individual eyepieces can be purchased from a set/family.
3. **Often,** eyepieces in a set get taller/bigger going from the shorter to longer focal lengths.
4. **Threaded for filters.** Almost all eyepieces have internal threads at the bottom of the barrel to accept filters. So, there are 1.25 inch and 2 inch filters. More on filters later.

Remember, there are 25.4 millimeters in 1 inch.
Notice that the barrel diameter is expressed in inches!

Eyepiece Set

Lowest Magnification

Set of Tele Vue Plössls



Highest Magnifications

2-inch barrel

Size gets larger but Magnifications decreases

SVBony Plössl **set** on Amazon about $80

Remember, there are 25.4 millimeters in 1 inch.

Optical/Mechanical Characteristics

Common Themes with Eyepieces

1. **Eye Relief** is the distance one has to place their eye over the eyepiece in order to see the whole eyepieces field-of-view. *Normally this distance decreases with shorter focal lengths.* Often, one has to really cram their eye up against eyepieces with focal lengths less than 7mm. Eye relief is measured in millimeters and is usually not indicated/engraved on the eyepiece—you will find it on the internet. You need an eye relief of around 15 to 20mm or greater for eyeglass wearers. There are *sets* of eyepieces that are designed with longer eye relief, but these eyepieces/sets are usually expensive.
2. **APPARENT Field-of-View (AFOV).** The size of the window that an eyepiece allows you to see through. *See upcoming slides.*
3. **Parfocal Design.** Some eyepiece sets are parfocal, which means that all the eyepieces in a set come to the same focus point/place when inserted into the focuser—so you only have to minutely refocus each eyepiece. This is a mechanical design consideration. My favorite eyepieces are parfocal (a mixture of Tele Vue eyepieces) and this makes observing easier.

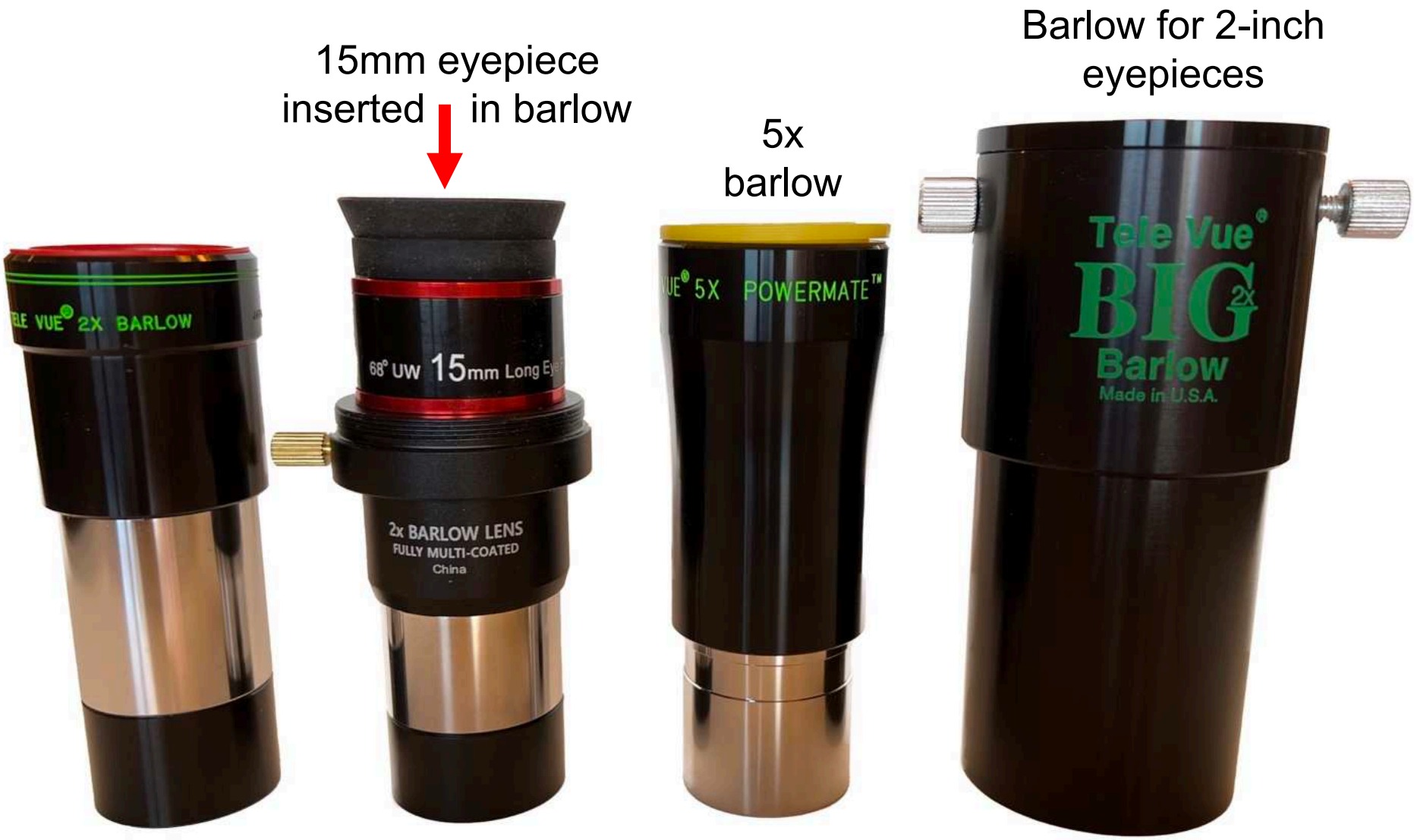
Remember, there are 25.4 millimeters in 1 inch.

Other Eyepieces+

Roundup

1. **A Barlow** is an “eyepiece” that is used to double (2x or more) the magnification of any eyepiece inserted into the barlow. Barlows are inserted into the focuser and an eyepiece is then inserted into the barlow. *One advantage of using a barlow is that the optical characteristics of an eyepiece do not change when in the barlow. For example, eye relief is not changed in an eyepiece used with a barlow.*
2. **20mm Eye Relief Sets.** There are families/sets of eyepieces designed so all of the focal lengths have the same, long eye relief, from about 15mm to 20mm. Yes, it is possible to design a short focal length eyepiece to have a long eye relief. These eyepieces are usually expensive.
3. **Zoom.** A Zoom eyepiece is an eyepiece whose barrel can be turned to change its focal length. This allows changing magnification without changing the eyepiece or the focus. A common range for a zoom eyepiece is from 8 to 24 mm. Tele Vue has a 3 to 6 mm zoom (expensive but a favorite of mine).
4. **Reticle.** A reticle eyepiece has crosshairs or other scales that can be illuminated and are used for various measurements or calibrations. This is beyond the basics.

Various Barlows



Eyepiece Filters

Summary: Don't need except for a Moon filter.

1. **Almost every eyepiece has internal threading at the bottom of the barrel to accept filters.**
2. **Moon Filter**. If there is one filter to have, it is a Moon filter to decrease the intensity of light from the Moon. When the Moon gets past a crescent, it is exceedingly bright through a telescope. There are two types, a **Neutral Density** filter that only lets in 5% or so of the light, or **two Polarizers** that can be rotated to change the amount of light that passes through.
3. **Colored Planetary Filters.** There are entire collections of colored planetary filters. Some sources say that specific colors can enhance certain detail on some of the planets. Maybe these help some individuals, but I can see the same detail without these filters. I have these filters, but **I never use them.**
4. **Deep sky filters** are specialty filters to help increase the contrast of a light polluted sky in order to see some fainter objects (nebulae/galaxies). The effect is not dramatic, so **I don't recommend these for newcomers.**

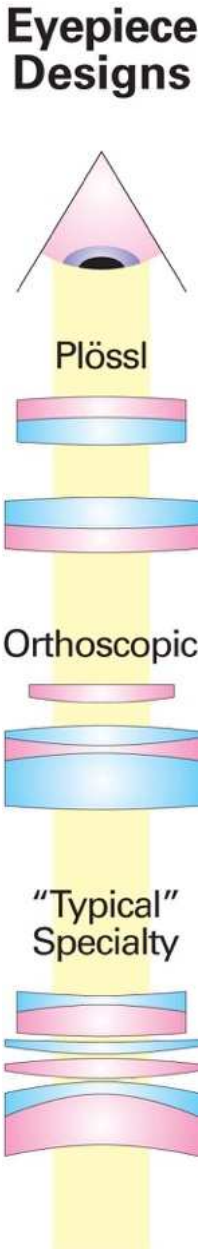
Moon filter a must!
Others a bust?

HOLD OFF on colored planetary filters and specialty nebula filters.

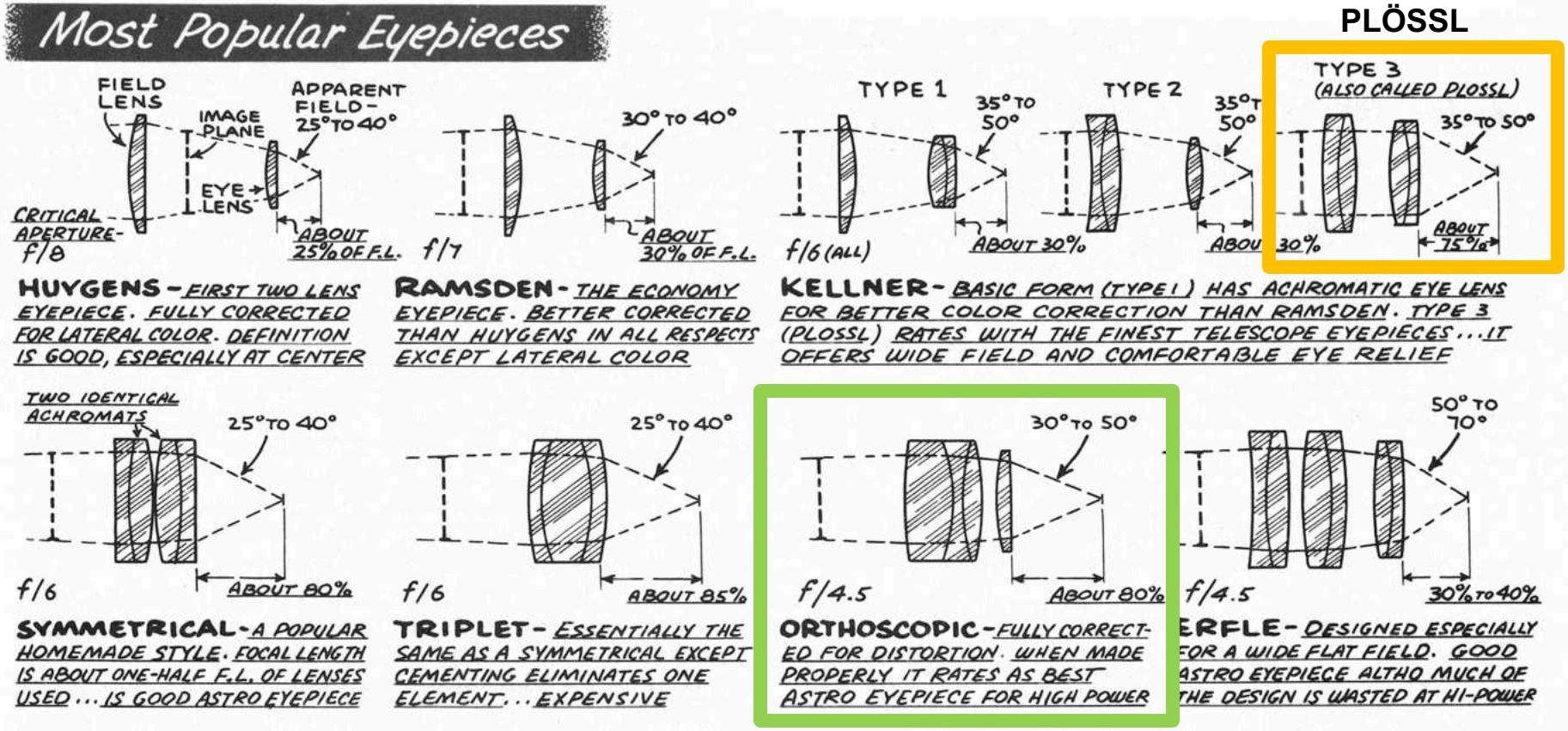
Two “Moon” Polarizing filters that can be turned to adjust brightness

Major Optical Designs and Specs

1. **In the beginning and for many years, the optical designs available for eyepieces were Huygens, Ramsden, Kellner, Plössl, Orthoscopic and Erfle. The Orthoscopic *was* considered the best. The Plössl has won as the present-day entry level eyepiece.**
2. **Orthoscopic.** 42° AFOV. This was considered the best eyepiece for a long time because of its superb optical characteristics. You can still buy them.
3. **Plössl.** 50° AFOV. It is the new "economy" eyepiece, but it provides good imagery—there is nothing wrong with it!
4. **Wide Fields (Specialty).** Manufacturers like to sell specialty eyepieces that sport AFOVs greater than 50° and/or with other characteristics like longer eye relief. Usually Expensive! Tele Vue popularized wide-field eyepieces and everyone else has jumped on the bandwagon.



History


Most Popular Eyepieces
PLÖSSL
FIELD LENS
IMAGE PLANE
APPARENT FIELD – 25° TO 40°
EYE LENS
CRITICAL APERTURE – f/8
ABOUT 25% OF F.L.
30° TO 40°
f/7
ABOUT 30% OF F.L.
TYPE 1
35° TO 50°
f/6 (ALL)
ABOUT 30%
TYPE 2
35° TO 50°
ABOUT 30%
TYPE 3 (ALSO CALLED PLOSSL)
35° TO 50°
ABOUT 75%
30%
HUYGENS – FIRST TWO LENS EYEPIECE. FULLY CORRECTED FOR LATERAL COLOR. DEFINITION IS GOOD, ESPECIALLY AT CENTER
RAMSDEN – THE ECONOMY EYEPIECE. BETTER CORRECTED THAN HUYGENS IN ALL RESPECTS EXCEPT LATERAL COLOR
KELLNER – BASIC FORM (TYPE 1) HAS ACHROMATIC EYE LENS FOR BETTER COLOR CORRECTION THAN RAMSDEN. TYPE 3 (PLOSSL) RATES WITH THE FINEST TELESCOPE EYEPIECES ... IT OFFERS WIDE FIELD AND COMFORTABLE EYE RELIEF
TWO IDENTICAL ACHROMATS
25° TO 40°
f/6
ABOUT 80%
25° TO 40°
f/6
ABOUT 85%
30° TO 50°
f/4.5
ABOUT 80%
50° TO 70°
f/4.5
30% TO 40%
SYMMETRICAL – A POPULAR HOMEMADE STYLE. FOCAL LENGTH IS ABOUT ONE-HALF F.L. OF LENSES USED ... IS GOOD ASTRO EYEPIECE
TRIPLET – ESSENTIALLY THE SAME AS A SYMMETRICAL EXCEPT CEMENTING ELIMINATES ONE ELEMENT ... EXPENSIVE
ORTHOSCOPIC – FULLY CORRECTED FOR DISTORTION. WHEN MADE PROPERLY IT RATES AS BEST ASTRO EYEPIECE FOR HIGH POWER
ERFLE – DESIGNED ESPECIALLY FOR A WIDE FLAT FIELD. GOOD ASTRO EYEPIECE ALTHO MUCH OF THE DESIGN IS WASTED AT HI-POWER

Fields of View

Your Window to the Universe
Apparent & True

1. **A Field-of-View** is the amount of the sky in arc degrees that you see when looking through an eyepiece/telescope. It varied depending on the optical design of your eyepiece AND the magnification achieved by your eyepiece.
2. The **eyepiece optical design dictates the APPARENT Field-of-View (AFOV)**. Plössls have a AFOV of 50° with other eyepieces having AFOVs of 68° to over 100°. Usually, you will have to obtain the AFOV of your eyepiece off the internet because eyepieces don't normally come with instructions or specifications, however, a few eyepieces have the AFOV engraved on the barrel.
3. **For any set/family of eyepieces, the TRUE Field-of-view DECREASES as the eyepiece focal length DECREASES—as the magnification increases.**
4. **Seeing it.** You can get a sense of an eyepiece's Apparent Field-of-View by looking through it and noting the outer circle that indicates its edge. For eyepieces with very large AFOVs, you often have to look inward to see the edge.
5. Generally, every eyepiece in a set/family has the same AFOV but the true FOV always gets smaller as the magnification increases using the shorter focal length eyepieces.

Same Magnification

But different <u>APPARENT</u> Fields-of-View (AFOV)

Plössl Eyepiece

TRUE Fields-of-Views

at different magnifications

45x
AFOV 50°
True **FOV 1.1°**

100x
AFOV 50°
True **FOV 0.5°**

Remember, the Full Moon
is 0.5° across or ½°

150x
AFOV 50°
True **FOV 0.33°**

As magnification increases, your TRUE Field-of -View ***always*** Decreases

Eyeglasses Wearers

1. **Eyeglass wearers** *do* **have a disadvantage when looking through eyepieces so if you can observe without having to wear eyeglasses, I recommend that you do so**—try it. It is usually recommended that individuals with astigmatism wear their glasses when observing but I have astigmatism and I do not wear my glasses when observing and it does not really affect the quality of my observing.
2. **Eye relief increases with longer focal length eyepieces** that deliver low magnification. Eye relief is okay around 15mm for eyeglass wearers. Usually, "normal" eyepieces with focal lengths starting at 20mm and greater have sufficient eye relief for eyeglass wearers.
3. **Long Eye Relief Eyepieces/Sets!** There are sets of eyepieces that have the same long eye relief for *every* focal length—these were more or less designed for eyeglass wearers. This eye relief is generally from 15 to 20 millimeters. Usually, these eyepieces are more expensive.
4. **Barlows don't change Eye Relief.** So, a barlow can be used to one's advantage to increase magnification without changing the eye-relief. Now, most barlows do not degrade optical performance.

Differences

Inexpensive compared to Expensive

1. **Cost varies from about $10 each to over $850 each**
2. **Wide Fields-of-View.** On average, you pay more and more for eyepieces with larger and larger Apparent fields-of-view. 50° is minimum—a Plössl. 60° to 100° are considered wide fields.
3. **Preminum Extras…**
   a. More Metal instead of plastic
   b. Chrome, thicker barrel
   c. Rubber eye guard
   d. Rubber grip
   e. Special optical coatings
   f. Blackened lens edges
   g. Adjustable eye relief slide
   h. Eye positioning guide
   i. Parfocal
   j. Safety undercut to prevent falling out of focuser
   k. Longer eye relief (often a family/series)

What do I use and why?

1. I have a set of 5 eyepieces in a case with a barlow and two polarizing filters (for Moon).
2. I chose these eyepieces over time because of their focal length spread, being parfocal, being 1.25 inch, eye relief and suitability to my eyes.
3. The list is as follows and all are Tele Vue eyepieces:
    1. **Tele Vue Panoptic 24mm/68°**
    2. **Tele Vue Panoptic 19mm/68°**
    3. **Tele Vue Nagler 13mm/82°**
    4. **Tele Vue Nagler 9mm/82°**
    5. **Tele Vue Nagler Zoom 6 to 3 mm/50°**
    6. **2x Tele Vue Barlow**
    7. **Two Polarizing filters for Moon**
    8. **About $1800 worth**

Best Deal for Plössl Family

SVBONY Multi Coated 1.25 inches Plossl Eyepieces 6.3mm 10mm 12.5mm 20mm 32mm 2X Barlow Astronomical Telescope Accessory Kit

Visit the SVBONY Store

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Eyepieces are mine!

If astronomy becomes your hobby, you might sell your scopes but most keep their eyepieces!

4-Point Eyepiece Summary

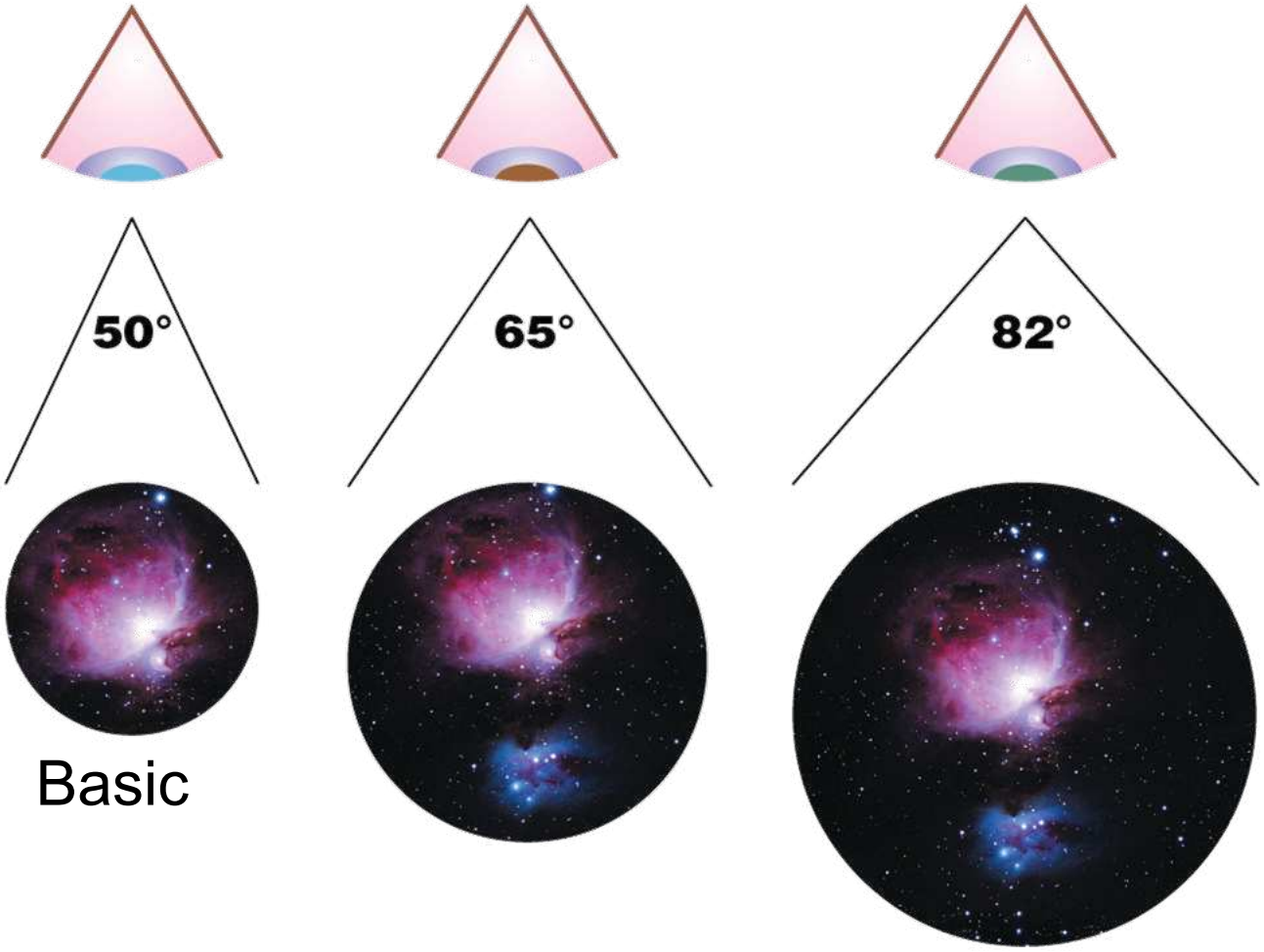
1. **Magnification.** The lower the eyepiece focal length (engraved on the eyepiece), the higher the telescope magnification
(Telescope magnification = ***Telescope*** focal length ÷ ***Eyepiece*** focal length

2. **Eye Relief** is the distance you place your eye from the top eyepiece lens to see the "whole" image. Generally, you have to place your eye closer and closer to the eyepiece for shorter eyepiece focal lengths.
Around a 20mm distance (3/4 inch) is considered comfortable and suitable for eyeglass wearers. Some eyepieces are designed to specifically have longer eye reliefs (like the 20mm).

4-Point Eyepiece Summary

3. **Eyepiece Apparent Field-of-View** is the size of the window an eyepiece provides when you look through it.

The ”basic” and “standard” is 50°. Prices go up after that!



Basic

4-Point Eyepiece Summary

4. The **Plössl** eyepiece is the basic and standard eyepiece today. Plössl is the name of the design and represents a specific arrangement of the 4 lenses that make up this eyepiece. The Plössls are good eyepieces with 50° apparent fields-of-views. Their biggest disadvantage is that they have very short eye reliefs for the shorter focal lengths.

Plössl set.
$76 by SVBony at Amazon

AFOV 50°

AFOV 68°
17mm Eye Relief
Specialty Eyepiece

Best value.
$130 by SVBony at Amazon