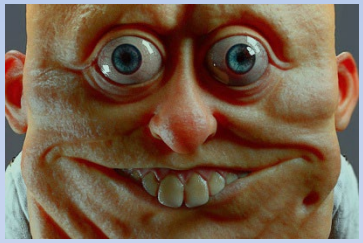
Astronomical Telescope Eyepieces

Everything (or at least some) you wanted to know but were afraid to ask.

Considerations

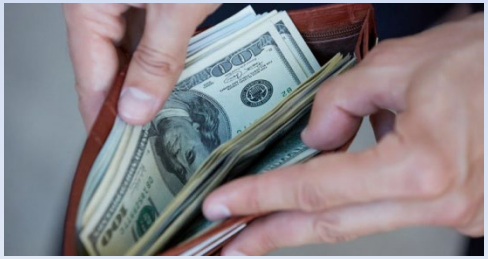
- Your Telescope

- Your Eyes



- Your Use

- Your Wallet



Important Terms

Focal length

The focal length of an eyepiece is the distance from the principal plane of the eyepiece where parallel rays of light converge to a single point. When in use, the focal length of an eyepiece, combined with the focal length of the telescope objective, **determines the magnification**. It is usually expressed in millimeters when referring to the eyepiece alone.

Field of View

The field of view, often abbreviated FOV, **describes the area of a target that can be seen** when looking through an eyepiece. The field of view seen through an eyepiece varies, depending on the magnification achieved when connected to a particular telescope, and also on properties of the eyepiece itself.

Actual field of view

The angular size of the **amount of sky that can be seen** through an eyepiece when used with a particular telescope, producing a specific magnification. It ranges typically between 0.1 and 2 degrees.

Apparent field of view

this is a measure of the **angular size of the image** viewed through the eyepiece, in other words, how large the image appears (as distinct from the magnification). The measurement ranges from 30 to 110 degrees.

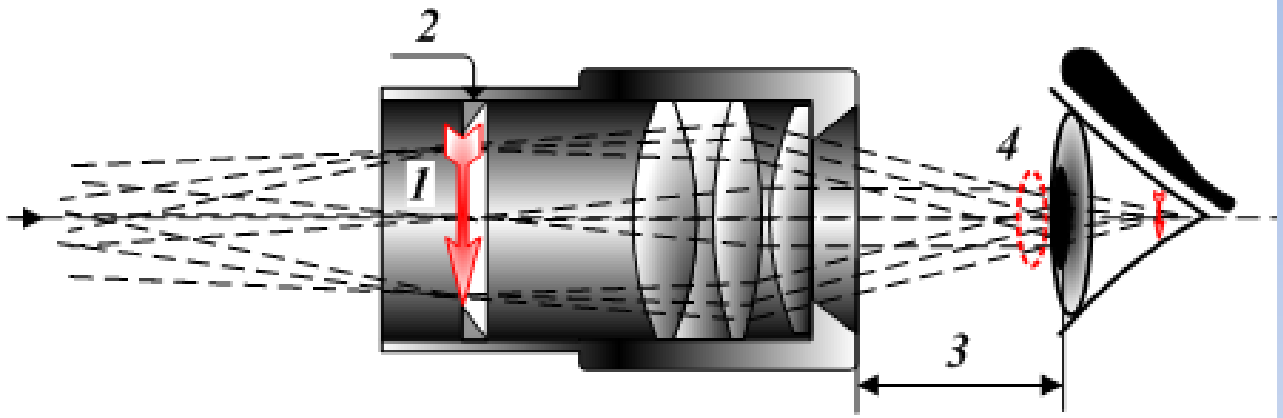
Simulation of views through various telescope eyepieces

Left image shows image through an eyepiece with a narrow apparent field of view.

Center image shows image through an eyepiece of the same focal length but wider apparent field of view, and how the image is larger and shows a greater area.

Right image shows image with the same apparent field of view as the center image, but shorter focal length giving greater magnification. The result is the same true field of view as the first image but at greater magnification.

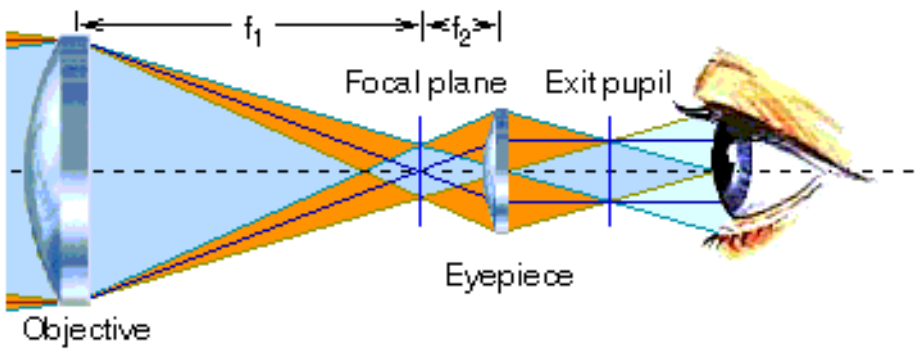
The Eye Relief



1 Real image **2** - Field diaphragm **3** - Eye relief **4** - Exit pupil

The eye needs to be held at a certain distance behind the eye lens of an eyepiece to see images properly through it. This distance is called the eye relief.

Two Common Issues



The **kidney bean effect** occurs when the exit pupil is very large and close to the size of eye pupil

This appears to the observer as a giant kidney bean shaped dark region that meanders around the field as head moves.

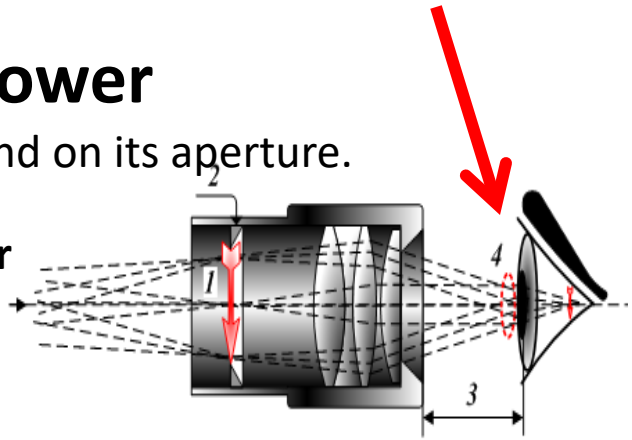
In some long f.l or wide angle eyepieces, it is sometimes necessary to move the eye closer to the eyepiece in order to see the edge of the field.

The **"blackout" effect** mainly arises with **eyepieces** of large eye relief and exit pupil or barlowing a low focal **eyepiece** such as a 35 mm. Blackouts aren't a characteristic of the eyepiece, they're simply the observer holding his eye too close to the eyepiece.

How Exit Pupil Relates to Power

The powers at which a telescope will work well depend on its aperture.

The exit pupil must be smaller than the pupil of your eye, or else some of the light rays will not make it into the pupil (light will be wasted).



Exit pupil size is calculated in millimeters using these formulas

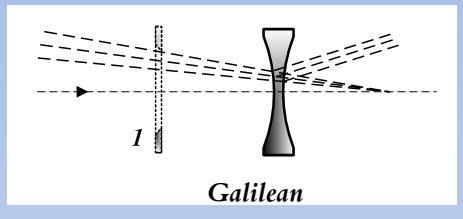
$$\textbf{Exit pupil size (mm)} = \frac{\textbf{Telescope aperture in mm}}{\textbf{Telescope magnification}}$$

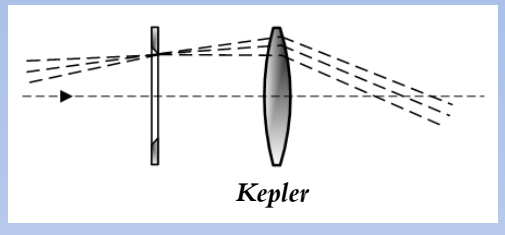
$$\textbf{Exit pupil size (mm)} = \frac{\textbf{Eyepiece focal length in mm}}{\textbf{Telescope f-ratio}}$$

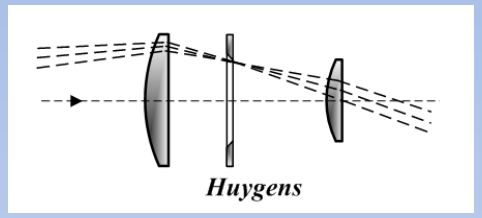
$$2.54\text{mm} = \frac{203\text{mm (8” Reflector)}}{100\text{X}} \qquad 3.20\text{mm} = \frac{32\text{mm}}{\text{f/10}}$$

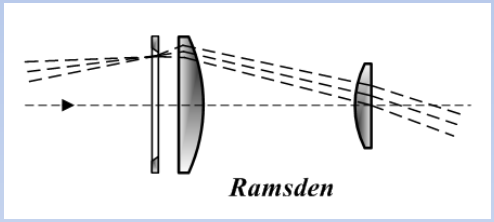
$$1.27\text{mm} = \frac{127\text{mm (5” Refractor)}}{100\text{X}} \qquad 4.57\text{mm} = \frac{32\text{mm}}{\text{f/7}}$$

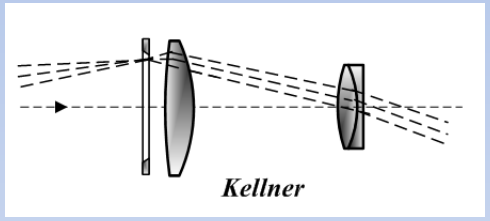
Optical Designs

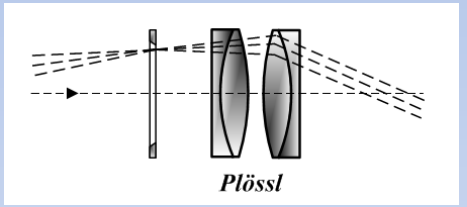


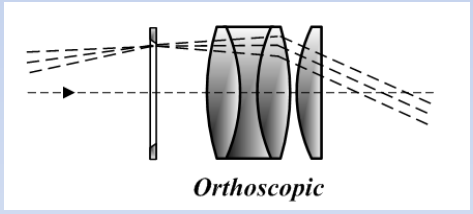


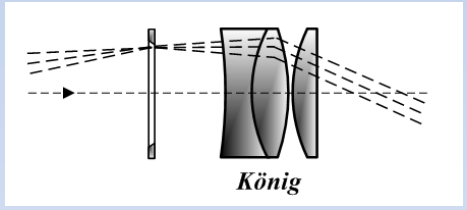


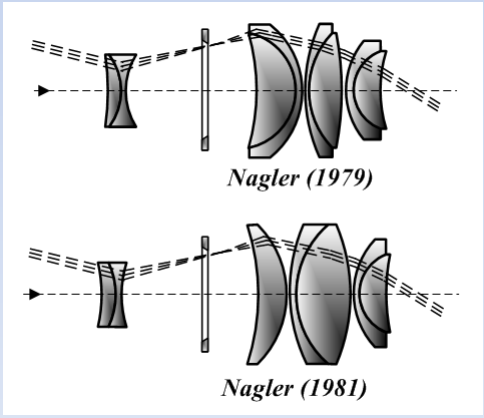


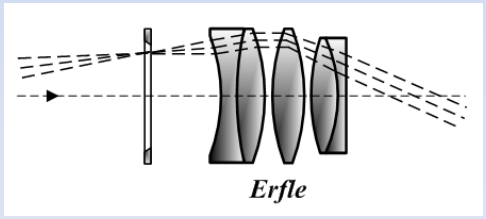


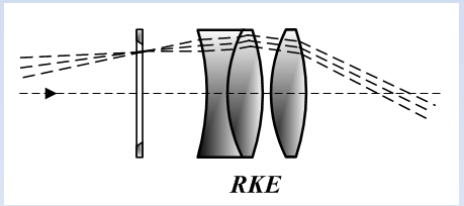










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Practical Focal Lengths for Eyepieces

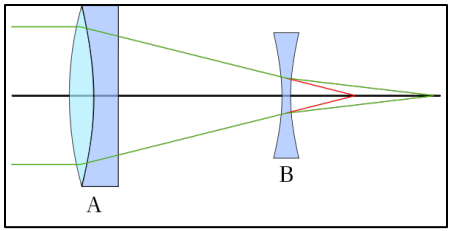
Power Range	Eyepiece (f/4 Telescope)	Eyepiece (f/8 Telescope)	Eyepiece (f/10 Telescope)	Eyepiece (f/15 Telescope)
VERY LOW	16 - 28mm	32 - 56mm	40 - 70mm*	60 - 105mm*
LOW	8 - 16mm	16 - 32mm	20 - 40mm	30 - 60mm
MEDIUM	4 - 8 mm	8 - 16mm	10 - 20mm	15 - 30mm
HIGH	2.8 - 4mm*	6 - 8mm	7 - 10mm	10 - 15mm
VERY HIGH	2.0 - 2.8mm*	4 - 6mm	5 - 7mm	7 - 10mm

*Eyepieces in these ranges are not normally practical with a 1.25” barrel.

Barrel Sizes

How Many Do I Need?

Barlow Lens



(A) without (red) and with (green) a Barlow lens optical element (B)

By using a barlow lens you can get away with having fewer eyepieces in your collection

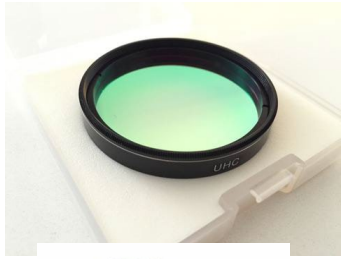
Filters


Filter No.12
Filter No.23A
Filter No.21
Filter No.56
Filter No.82A
Moon & Skyglow

Not Useful	Good	Excellent	Probably the Best

Wratten Number and Color	Moon	Mercury	Venus	Mars	Jupiter	Saturn
#8 Light Yellow	With small telescopes			Maria, Dust clouds	Belts	
#11 Yellow-Green				Maria	Belts	Cassini Division
#12 Yellow			Improves contrast	Maria, Atmospheric clouds	Belts, Poles	
#15 Dark Yellow / Amber	Useful	Daylight	Low contrast clouds	Maria, Dust clouds, Polar regions	Belts, Poles, Festoons	
#21 Orange	Very useful	Daylight surface		Surface edge detail	Belts, Red spot, Festoons	Bands, poles
#23A Light Red		Daylight, Twilight		Maria and surface, Dust clouds, Polar caps	Blue clouds	Blue clouds
#25 Red		Daylight, Twilight	Upper clouds	Maria, Polar caps	Improves contrast	
#29 Dark Red			Terminator	Maria, Polar caps	Moon transits	Clouds
#38A Dark Blue			Upper clouds	Dust storms, Polar caps, Violet clearing	Belts, Red spot	Bands, rings
#47 Violet	Useful		Upper clouds	Clouds and haze above poles		Ring detail
#56 Light Green	Useful		Improves contrast	Dust storms, Polar caps	Red Spot	Bands, Poles
#58 Green	Useful		Improves contrast	Dust storms, Polar caps	Belts	White bands, Poles
#80A Blue	Very useful	Twilight surface	Upper clouds	High clouds, Ice caps	Rills, Festoons, Red Spot	Bands, Poles
#82A Light Blue	Useful	Twilight surface	Upper clouds	Polar caps, Surface	Belt transition	Band transition

Accessories



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Choosing Eyepieces for your Telescope- Shari

SAS-The-Use-of-Astronomical-Filters

Questions ?

PowerPoint Created by Richard Cofer

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