An Introduction to Eyepieces

Eyepiece Characteristics

- Focal length — Every eyepiece has a focal length, indicated in millimeters and marked on the top or side of the unit. Longer focal lengths (55mm to 28mm) provide lower powers and larger fields of view. Shorter focal lengths (12mm to 3mm) produce higher powers and smaller fields of view.

  To find the magnification that an eyepiece gives on a telescope, divide the focal length of the telescope in millimeters by the focal length of the eyepiece.
- Field of view — Each eyepiece has an apparent field of view (FOV), measured in degrees that is usually provided in the manufacturer's specifications. Standard designs have apparent FOVs of 45 to 55 degrees and wide-angle designs have over 70 degree apparent FOVs.

  To find the true FOV (the amount of sky being shown) that an eyepiece gives on a telescope, divide the apparent field of view by its magnification on that telescope.
- Barrel diameter — Most modern eyepieces use 1.25-inch barrels but some very wide field designs use 2-inch barrels. Many telescopes have 2-inch focusers that can also handle the 1.25-inch eyepieces using an adaptor. Some 1.25-inch eyepieces have 2-inch collars that allow their use in both sizes of focuser.
- Eye relief — This is the distance the eye must be from the eyepiece in order to view the whole field, usually expressed in millimeters. For some designs this depends on the focal length of the eyepiece and high power eyepieces have uncomfortably short eye relief. Eye relief of more than 15mm is required to observe comfortably while wearing glasses.
- Coatings — All modern eyepiece lenses are coated to improve light transmission and reduce flaring. Top quality eyepieces are multicoated and some are "fully multicoated", a more expensive process in which every air-to-glass surface is treated.

Eyepiece Designs

Standard Field (35 – 50 degree apparent field of view)

- Kellner and Modified Achromat: 35 to 45 degrees, economical three-element design, some chromatic aberration, best for long focal length scopes
- Orthoscopic: 45 degrees, four-element design, good eye relief
- Plossl and variations: 50 degrees, four-element design (some variations have more), excellent contrast, less eye relief at shorter focal lengths (<13mm)

Wide Field (60 – 70 degree apparent field of view)

- TeleVue Panoptic, Meade Superwide, Vixen Lanthanum Superwide, Pentax XL: 65-68 degrees, usually six-element design, minimal edge aberrations, excellent for low to mid power wide fields of view, Lanthanums and Pentax Xl have 20mm eye relief at all focal lengths
- Konig: 60 to 70 degrees, four to five elements, fine edge performance
- TeleVue Radian: 60 degrees, six to seven-element design, high contrast images, excellent for high powers, 20mm eye relief at all focal lengths from 18mm to 3mm

Super Wide Field (80+ degree apparent field of view)

- TeleVue Nagler: 82 degrees, seven-element design, extremely wide field with sharp images from edge to edge, short focal length models are large and heavy, fairly expensive, Type 4 series (22mm, 17mm, 12mm) have 17mm of eye relief
- Meade UltraWide: 84 degrees, eight-element design

Choosing Eyepieces

Many telescopes come with a couple of budget Modified Achromat or Plossl eyepieces, usually a 25mm and a 10mm. Many people are in a hurry to add more and may like to own a complete series but a well chosen set of three or four is all that is really needed.

It is recommended that you use the provided EPs enough to learn exactly what they look like in your telescope so that you can determine what adding another specific EP will mean – provide a wider low power view, provide better contrast, etc.

If possible, it is very useful to think ahead and consider what a complete eyepiece set might look like before buying new eyepieces. Even if it takes months or years to complete the set, the result is usually better than buying them in an ad hoc fashion and ending up with a grab bag of EPs.

If you wear glasses and wish to leave them on while observing EPs with eye relief of at least 15mm are needed. At lower powers observers with severe astigmatism my need to keep their glasses on to keep stars looking sharp near the edge of the field even in a high-quality EP. Astigmatism is less of an issue at higher powers as the exit pupils are small and glasses may not be needed.

One eyepiece should be a low power one with a focal length of 30-35mm. For example, the 32mm Plossl design has the widest possible field for telescopes with a 1.25-inch focuser. This EP is useful in providing large fields for efficient starhopping as well as viewing larger objects. A non-driven telescope will also need to be nudged less often to keep an object in view with a wider field.

The EP used most often is usually a medium power one. One useful guideline is that a 2mm exit pupil optimizes the eye's ability to resolve detail and provides a very comfortable viewing experience. Exit pupil size depends on the focal ratio of a telescope – to determine the focal length of your "optimum" EP, multiply your focal ratio by 2. For example, an f/8 telescope results in a 16mm "optimum" focal length eyepiece – anything in the 14mm to 18mm range would be fine.

For higher power views of planets and the Moon choose shorter length focal lengths that give powers of 150x or more. Don't forget that the maximum useful magnification is considered to be 50 times the diameter of your objective in inches and seeing conditions usually limit useful magnifications to between 150x and 250x no matter how big your telescope is.

A cost-effective approach to high power views is to use a Barlow lens that is placed into the focuser before inserting an EP into the Barlow. A Barlow effectively increases the focal length of the telescope by some multiple and therefore increases the magnification of the EP being used. Barlows are available in many sizes from 1.8x to 5x with 2x being the most common. As they place more optical surfaces into the light path it is important to choose a high quality one.

If you decide to use a Barlow to enhance the powers available with an eyepiece set it is important to choose the eyepieces carefully to avoid duplication. For instance, with a 2x Barlow it makes little sense to have a 20mm and a 10mm eyepiece as the 20mm EP with the 2x Barlow provides the same magnification as the 10mm EP.

References

- *The Backyard Astronomer's Guide* by Terence Dickinson and Alan Dyer
- *Choosing Your Telescopes Magnification*, an excellent article on the televue.com website