Choosing and Using Binoculars for Astronomy

Novice amateur astronomers can feel overwhelmed by the wealth of astronomical equipment available and by the vastness of the night sky. However, getting started in astronomy is easy. For example, beginners commonly are surprised to learn that binoculars are the perfect first telescope. The wide field of view allows you to find an object even if you are a little off target. The wide view can represent a significant chunk of typical constellations, meaning that it is easy to relate what you see to naked-eye views and to whole-sky maps such as those found in the *Observer's Handbook* or in *Sky News* magazine. The right-way-up, two-eye, low-power view is a still a big step away from the naked-eye view.

Using binoculars teaches skills that are valuable at a telescope including knowledge of the layout of the night sky, the orderly march of stars from east to west during the course of a night, the different constellations that are prominent during the various seasons of the year. The low power of binocular views reinforces the fact that sometimes the best magnification in a telescope is a very low one (quite different from how small department or camera store telescopes are pitched to an unsuspecting public).

Binocular Parameters

Every binocular has a two-number designation, such as 6×30 or 10×50. The first number is the *magnifying power* or magnification. The second is the diameter of the objective (front) lenses in millimeters — the *aperture* of each lens. The bigger the objective lenses, the brighter the stars. Most astronomical objects are hard to see not because they are small and need more magnification, but because they are faint and need more aperture. Binoculars with an aperture of 50mm gather twice as much light through each lens as 35mm binoculars.

Generally, the best binoculars for night viewing have moderate magnification and large objectives; 10×50's are ideal. Magnifications higher than 10 are tough to hold steadily and lead to narrow fields of view, while the light grasp of lenses smaller than 50 mm means that fainter objects may be invisible.

Field of view typically is expressed in degrees or as a certain number of feet at 1,000 yards (for example, 325 feet at 1,000 yards). To convert feet at 1,000 yards into degrees, divide the number of feet by 52.5 (e.g. 325/52.5 = 6.2°). Most binoculars have a field of view around 6° or 7°. High-power models will shrink this while wide-angle models will take in 8° to 10°.

The exit pupil describes the width of the beam of light leaving the eyepiece. It is calculated by dividing the aperture by the magnification. All 10×50 binoculars have an exit pupil of 5mm and 7×50s have exit pupils of about 7mm.

As our eyes adapt to darkness, the pupils dilate to let in more light. Most people younger than 30 who observe under a dark, rural sky will have pupils that dilate to about 7mm. They can take full advantage of binoculars that produce an exit pupil of 7mm. By the time you're 40 or older, the pupil probably won't dilate beyond 5mm. If you use binoculars with an exit pupil wider than your pupil size, some of the incoming light won't get into your eyes and images will appear dimmer.

Binocular Features

Most binoculars are center-focus, meaning you turn a knob in the center to focus both eyes at once. The right-hand eyepiece is also individually focusable so you can correct for differences between your eyes; this should only have to be done once. Binoculars contain a set of prisms that fold the light path internally and make the image appear right-side up. These prisms come in two varieties. Roof-prism models have straight barrels and are more compact. They tend to be more expensive and produce slightly dimmer images, making them less desirable for astronomy. Porro-prism binoculars have a zigzag shape and usually are heavier and bulkier than roof-prism models. Most higher-quality binoculars are made of BaK-4 glass instead of BK-7.

Also, look for antireflection coatings, which increase light transmission and contrast, both of which are especially important in astronomy. "Multicoating" is the best kind. In top-notch models, all glass-to-air surfaces are multicoated. We show you later how to verify that all surfaces are coated.

Rubber eyecups are useful, especially if artificial lights intrude on your observing site. Be sure that they fold down if you need to wear glasses for astigmatism.

Selecting Binoculars

For reasonable quality, try to spend at least $100 on a pair of new binoculars. Good 10X50's will probably cost at least $160. Very good 10X50 binoculars with better antireflection coatings, improved eyepieces, larger prisms, and more rigid construction will cost more than $200. Zoom binoculars generally do not have the same optical quality as fixed magnification binoculars, so it's probably best to ignore them.

The following tests will enable you to judge the quality of any binoculars, new or used.

1. Pick up the instrument and compare its overall workmanship; some brands will seem better made than others will. Hold the two barrels and try to twist them slightly. If there is any play in the joints or anything rattles, reject the pair. Move the barrels together and apart; the hinges should work smoothly, with steady resistance. So should the focusing motions for both eyepieces. On center-focus binoculars, the eyepiece frame should not tilt back and forth when you turn the focus in and out.

2. Look into the large objective lenses with a light shining over your shoulder so the inside of the barrel is illuminated. Reject the pair if a film of dirt or mildew is visible on any glass surface. (Dust on the outside is not a problem.) Look at the two reflections of the light from the front and back of the objective lens, which will appear to float a little above and behind it. If the lens is antireflection coated, both reflections will have a blue, purple, amber, or greenish colour, instead of white. Move the binoculars around until you see a third reflection deep inside, from the first surface of the prisms. This too should be colored, not white. Then, still looking in the front, aim the eyepiece at a nearby light bulb. Move the glasses around to view a row of internal reflections. The ratio of colored to white images suggests the percentage of coated to uncoated surfaces.

3. Turn the binoculars around and repeat your examination of lenses and coatings from the eye end. Then, holding the glasses away from your face, aim them at the sky or a bright wall. Look at the little disks of light seen floating just outside the eyepieces. These are the *exit pupils*. If they have four shadowy edges, rendering them squarish instead of round, the prisms are too small and are cutting off some light. In good binoculars, the exit pupils are uniformly bright to their round edges. As well, they should be surrounded by darkness, not by reflections from inside the barrels.

4. Look through the binoculars. Adjust the separation of the barrels to match the spacing of your eyes, then focus each side separately. A filmy or gray image indicates an unacceptable contrast problem. If you have to wear glasses to correct for astigmatism, make sure you can get your eyes close enough to view the full field with the glasses on. If your glasses do not correct for astigmatism, you can take them off. If you see a double image or feel eyestrain as your eyes compensate for the binoculars' misalignment, do not buy the binoculars.

For a better test, first make sure the barrels are adjusted for the separation between your eyes, and then look at something distant through the binoculars. Slowly move them a 10 to 20cm out from your eyes while still viewing the object. It should not become obviously double. Careful! Your eyes will automatically try to fuse even a bad double image. At times, even a correctly aligned pair of images will look double for brief moments before your eyes get them into registration.

Misalignment due to flimsy prism supports is the *worst* problem of cheap binoculars; even a small knock can render a working pair worthless. Instruments that are more expensive should survive minor accidents better.

Notice the size of the field of view: the wider the better. However, the edges of a wide field usually have poor optical quality. Sweep the field at right angles across a straight line, such as a doorframe or telephone wire. Watch whether the line bows in or out near the edges. This *distortion* should be slight.

Look at sharp lines dividing light and dark, such as dark tree limbs or the edge of a building against a bright sky. Do they have red or blue fringes? No instrument is perfectly free of this *chromatic aberration,* but some are better than others.

Under the Stars

A star at night is the most stringent test of optical quality, so try the binoculars on real stars if you can. If not, look for an 'artificial star' such as sunlight glinting off a distant piece of shiny metal. Center it in the field of view. Looking with one eye at a time, can you bring it to a perfect point focus? Or, as you turn the knob, do tiny rays start growing in one direction before they have shrunk all the way in the direction at right angles? This *astigmatism* is especially bothersome when viewing stars, and binoculars that are completely free of it can be forgiven some other faults.

Move the star from the center of the field to the edge. It will go out of focus unless you have a perfectly *flat field* and freedom from various other aberrations. As a rule of thumb, no degradation should be visible until the star is at least halfway to the edge of the field.

Using Binoculars

Binoculars will show the Moon in crisp detail. Watch shadows creep across craters as the Moon's phase changes. View delicate earthshine glowing on the dark side of a crescent Moon. Follow the phases of Venus and track the orbital motions of Jupiter's big moons. Binoculars will help you pick out Mercury in the twilight sky and spot the faint outer gas-giant planets, Uranus and Neptune, as well as the brighter asteroids. On bright comets, binoculars magnify enough to show detail while providing a wide-enough field of view that you can see the comet's head and most or all of the tail at once.

Outside the solar system, binoculars work best on large deep-sky objects like big star clusters such as the Pleiades in Taurus or the Beehive in Cancer, which cover too much sky to see all at once through typical telescopes. Binoculars provide stunning views of Milky Way star fields and some of the larger emission nebulae that dot our galaxy's spiral arms. They'll show you the Andromeda Galaxy (M31) and the Pinwheel Galaxy (M33) in Triangulum.

Binoculars work best if you can hold them steadily. Tripod mounts are ideal, but outdoor chairs, normally used only for summer sunbathing, make good observing chairs since the armrests are perfect for resting elbows. Use a blanket or old sleeping bag to keep yourself warm while scanning the skies in this manner.

Find out more:

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