Binocular Tests and Comparisons
Oberwerk 25x100 IF
Celestron 25x100 Skymaster
Garrett Optical 20x80 Gemini
Oberwerk BT100 Binocular Telescope

by Ed Zarenski

I picked up the Oberwerk 25x100 IF in spring 2005 soon after I wrote a CN report comparing the Celestron Skymaster 25x100 and the Oberwerk 22x100. More recently I acquired the Garrett 20x80 Gemini. This report uses new data that has been compiled over a 9 month time frame and highlights the Oberwerk 25x100 IF and shows comparisons to the other binoculars titled above. Refer to the bibliography for reference to the previous report **100mm Binoculars – What Can You See?** for additional data.

Binoculars included in this report: All the primary comparisons in this report are with the Oberwerk 25x100 IF doublet, Celestron Skymaster 25x100, Garrett Optical 20x80 Gemini triplet and Oberwerk BT100 binocular telescope. Among other binoculars used for some performance indications are references to Oberwerk Standard 20x80, Fujinon FMT-SX 16x70, Oberwerk 15x70, Nikon 12x50 SE and Oberwerk Mariner 10x60.

This report discusses some of the relevant aspects of binoculars, such as eye relief, inter-pupilary distance, field of view, coating quality, weight and mounting. In addition, observations are used to record image sharpness, light gathering, and contrast. Much of this report concentrates on the visual capabilities of these binoculars. More than anything else what stood out in my mind was the dramatically increased ability that a 100mm binocular can provide to the viewing experience. Hopefully, this report will provide the reader with useful information about the performance that can be expected from a 100mm binocular and some watch-outs to be aware of if you consider going this route.

I always start out with the intentions to review a binocular and find that the only way to give that data relevance is to incorporate comparative data from other binoculars. Some information from previous testing is used here and in some cases I recorded views of the same test objects with the new Oberwerk 25x100 IF and Garrett 20x80 so I am able to make comparisons. In many cases a celestial object must be viewed more than once to get a reliable record of the best view. So many factors come into play; seeing, transparency and even physical wellness on the given night. The best recorded observation is one that can be compared to previous recordings for determination of best observation. Also, I find it necessary to explain many of the concepts and methods of measurement. A test value may not be meaningful unless the reader can understand how it was obtained, why, and what it's result means. It's a long read, 40+ pages, but throughout you will find that I review a lot of information about all these binoculars.

Clear Skies, and if not CloudyNights
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INTRODUCTION

25x100s are much larger than all 70mm binoculars and even still quite a bit larger than many of the 20x80s. These are big, real big. None of these 100mm or 80mm binoculars would be considered hand-holdable. I'm sure there are some people who will claim they can hold a 20x80 for scanning the skies. I will not discuss hand holding any of these.

Oberwerk 25x100, Garrett Optical 20x80, Oberwerk 15x70, Garrett Optical 10x50

100mm versus 70mm or 80mm

The number of fainter stars seen in open clusters with the 100mm binoculars is far greater than the number seen with 15x70s or 20x80s. Using BT100s with eyepieces ranging from 31x to 44x, the number of stars seen and the faintest magnitude reached increases dramatically even over both of the other fixed power 25x100mm binoculars.

When it comes to how much can be seen, in just about every side-by-side viewing session, the larger binoculars saw more, and easily, not just barely. Fujinon 16x70s have a finer image, but the 20x80s and the 25x100s will see more. If there are no serious optical deficiencies present that take away too much from the observation, then even if you didn't add aperture for most objects adding magnification allows you to see more.

But there are exceptions. Certain types of objects demand superior contrast and the bright image from a larger exit pupil. My fixed power binocular of choice for observing the North America and Veil nebula would be the Fujinon 16x70.

These fixed power 100mm binoculars provide about a 2.5° field of view at low power. The BT provides 2.5° at low power 24x to 25x and would provide a 1° field of view at about 62x. Highly corrected wide field eyepieces can be used to get a wider field of view at a substantial cost above initial investment. Most people are using fixed binoculars and prefer the wider field of view. The 20x80s have just a bit wider fov at 2.9°.

More power is not always the answer to see an object. These featured binoculars provide exit pupils ranging from 4mm at fixed low power to high powered BT100 combinations with 4mm to about 2mm exit pupil. In most cases, for observing more stars you will benefit by more power or higher magnification. But the BT100, even though capable of higher powers, with 26mm eyepieces at 23.8x gives a 4.2mm exit pupil in a fine instrument with high contrast, a better suited power for viewing faint extended objects.

Binocular Summation
A binocular allows you to see with both eyes. Binocular summation allows our brain to process a signal from two eyes giving our brain more information. The end result is we see more than what would be seen with one eye from one aperture. Some studies show, depending on the type of objects observed, that summation can range up to +20% for light gathering to +40% for contrast beyond what is seen in a single 100mm aperture. Percent increases are based on what could be seen in equivalent area of aperture. So for a 100mm objective, rather than (nominal) 10,000 sq mm, in a binocular the effective area for information gathering is 12,000 sq mm or 14,000 sq mm or the equivalent of what would be delivered from as much as a 118mm aperture.

The Celestron 25x100 is smaller than the Oberwerk 25x100. Shown here for comparison next to a Celestron 15x70 which are the same size as the Oberwerk 15x70, you may be able to see some difference.

Oberwerk 25x100 IF
These are really big. They are just over 17 1/4" long, 9 1/4" wide and 4 1/2" high. The spec says they weigh 10 pounds. They are waterproof. These come in a real nice hard storage case.

This Oberwerk 25x100 was the instrument used for my recent deep sky object tour, Galaxy Hunting with Big Binoculars a report found in the CN Binocular forum through "Best Of" Observing.

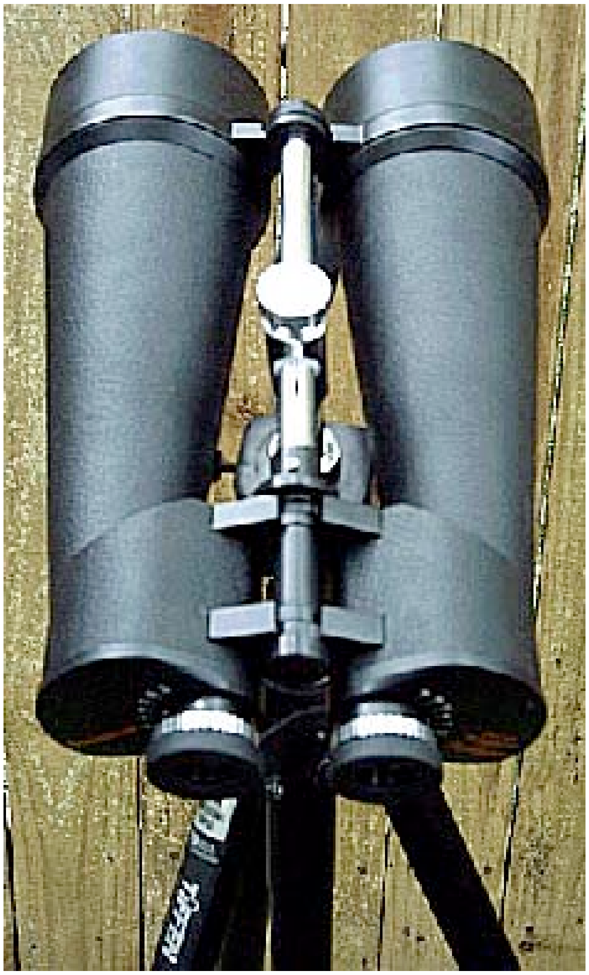
Faintest stars seen with the Oberwerk 25x100 are about mag 12.0 to 12.5. On-axis resolution is very good. Sharpness across the field is good to 85-90%. Contrast and light transmission of this binocular make it a great choice for deep sky viewing.

The Obie 25x100 IF measures approximately f/4.85.
The center vertical mounting post was simply too short.
The Oberwerk 25x100 coatings are similar to the BT100 coatings.

This binocular sells for $425.

Celestron 25x100

This binocular weighs in at 9.75#. At 16" long, it is slightly smaller in overall dimension than the Oberwerk 25x100. It is waterproof.



The Celestron 25x100 is an individual focus binocular. Overall the view was good, but it had some problems that the left eyepiece would not achieve a pinpoint star focus and point collimation was just about at the limit acceptable. This lack of pinpoint focus may be indicating an eye lens not seated properly. Had these been a purchase, I would have sent them back.

The binocular is covered with a glue-down pebble finish. There is no readily accessible external prism adjustment screws.

I thought the exterior construction around the prism housings was a bit chintzy, not what I would have expected in a $300 binocular. They come in a nylon suitcase.

Center vertical mounting post was too short.

Faintest stars seen with the Celestron 25x100 are about mag 12.0. On-axis resolution is slightly less good. Sharpness across the field is good to 70%, but poor beyond 80%. Contrast and light transmission of this binocular make it a great choice for deep sky viewing.

The Celestron 25x100 is approx. f/4.4.
No undesirably noticeable pincushion or barrel distortion.

There are considerable differences in advertised eye relief, fov & coatings with reality.

This binocular did sell for $349. Currently $329 and it can be found for as little as $248.

Garrett Optical Triplet 20x80 Gemini
These binoculars are about 12 3/4" long, 8 3/4" wide and 4" high. Since the binocular body is smaller than the 100s, the short vertical mount post does not cause as much problem. They are waterproof.

GO 20x80 weight is about 7.5#. That allows greater flexibility in mounting options. It seems the difference between 7.5# and 10# is a threshold that once crossed requires much more substantial support.

My sample of the GO 20x80 had a significant issue with off-center sharpness across the field of view. I do not expect this would be present in every sample. If the sharpness were centered, the sharp area would be about on par with the Celestron 25x100.

Faintest stars seen with the GO 20x80 are about mag 11.3 to 11.5. On-axis resolution is very good. The contrast and light transmission of this binocular make it a great choice for deep sky viewing. The Garrett 20x80 Gemini is approx. f/4.6.

This GO 20x80 was the instrument used for my recent deep sky open clusters tour A Prolific Night of Viewing with the Garrett Optical 20x80, a report found in the Binocular forum through "Best Of" Observing.

These come in a real nice hard storage case. This binocular sells for $279.

Oberwerk BT100 Binocular Telescope

The BT100 is a different animal altogether than any other 5# to 12# binocular in the 80mm to 100mm range. The BT100, at 26# (12kg), is heavier than my largest telescope, a 1200mm f8 6" refractor. The BT100 dwarfs even the Oberwerk 25x100. This binocular comes in a unitized housing that measures approximately 24” x 12” x 6”. The integral mount adds to the overall dimension. You must first set out the custom tripod then attach the BT100s. You would not move it mounted as it is very much top-heavy.

My BT100 is a straight thru viewing binocular. The custom tripod requires the need to sit in a chair under the binocs to view at any altitude. Actually, I’ve found for most altitudes this can be very comfortable.

The BT100 is F=620mm, f/6.2, with semi-apochromatic triplet objectives. It comes standard with two sets of WA eyepieces, a 24.5mm eyepiece that gives 25x at 2.5° Tfov and a 10mm eyepiece that gives 62x at 1° Tfov. Various other models of the BT100 have slightly different focal lengths and come with different eyepieces. The BT100 with non-proprietary helical focusers accept any 1.25" eyepieces. Some may be too tight to fit, but there are a fast array of choices available.

It's FMC, very well baffled with coatings that rival Fujinon. There are four baffles between the objective lens and the prism housing. It is not waterproof.

My BT100 binocular shows a bit of difficulty with the supplied 62x eyepieces due to minor mis-collimation and slight astigmatism.

For detailed work I have been using various plossl eyepieces and others that give a somewhat narrower field of view. My favorite eyepieces in this instrument are:
26mm TV plossls for a 4.2mm exit pupil that give 24x with a 2.2° Tfov;
20mm TV plossls for a 3.2mm exit pupil that give 31x with a 1.67° Tfov;
14mm TV Radians for a 2.4mm exit pupil that give 44x with a 1.4° Tfov;
The views are simply stunning.

One of the best high-powered views ever in the BT100 was with a 12.5mm ortho at 50x when I resolved some 30 to 40 stars in the very dense open cluster M11. The best low power views I've had were with the 26mm TV plossls that allowed seeing the Merope and the Rosette nebulae. Those same 26mm TV plossls allowed me to see M74 in mag 5.5 skies. It was the very faintest of a smudge, easily lost.

The BT100 binocular with tripod and mount sells for $1595 without $89 finder scope. Compare that to the full cost of an Oberwerk 25x100 IF ($425) mounted on a Bogen 501 fluid head ($140) attached to a Bogen 3246 tripod ($218), for a total of $783. It can be purchased for $100 less without the custom surveyor tripod, but that custom tripod is well worth more than the $100.

MECHANICAL AND OPTICAL OPERATION

Focus and Diopter
These are all individual focus binoculars.

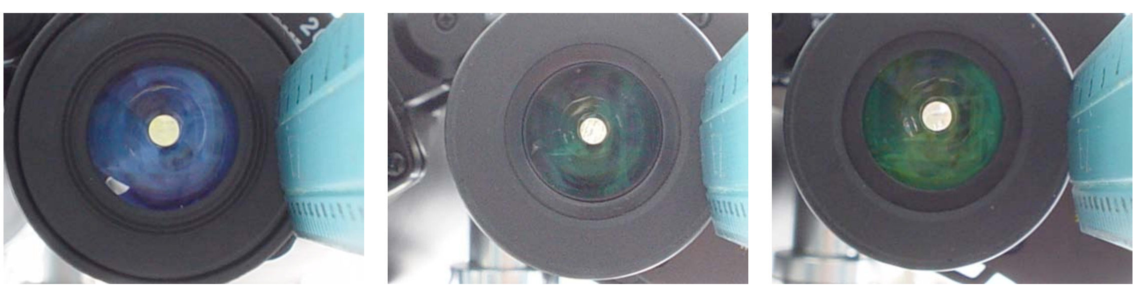
Oberwerk 25x100 IF Focus is a very nice pinpoint in both sides. When I'm focused at infinity both diopters are reading between +2.5 and +3 on the scale when I was wearing my corrective lenses. The total dial range is about 7 to 8 ticks in each direction from zero. On an IF binocular that means you get more close focus range in the minus diopter direction. When using my best binoculars with my glasses on, I'm right on zero. This should not be a problem. I did not try viewing without my glasses. That might present some problems depending on your prescription.

BT100s are equipped with non-rotating individual focus helical focusers. That means if you have eyepieces with eye guard wings attached, the eyepieces don't rotate as you focus. The focus range seems unlimited, but it actually does have a limit. There is almost 28mm of focus travel in the BT100, so there is plenty of room for focusing. Some small eyepieces can be very difficult to remove if inserted all the way. Since there is so much focus travel to accommodate, I find it easy enough to just not stick eyepieces like the 12.5 UOs all the way into the barrel.

The GO 20x80 turns through _ of a full turn or 270° from close focus to infinity. The travel distance is 6.5mm of travel.

The Celestron 25x100 would not achieve precise focus in the left barrel.

Exit Pupils
The Oberwerk 25x100 exit pupils measured 4mm to within 0.05mm. The exit pupil in the Celestron measured 4mm but were not checked as precisely as these others. The exit pupils in the BT100 depend on the eyepiece in use and all measured to within 0.05mm of expected. The GO 20x80 exit pupils measured 3.85mm to 3.9mm within 0.05mm.



Focused at infinity all should be a 4mm exit pupil. Only the R photo is truly 4mm.
These photos were taken with the camera held tight against a small steel scale that kept camera distance constant to all three exit pupils, therefore scale is the same. Scaling the photos produces almost exact same results as actual measurements. The binoculars are 20x80 Ant, 20x80 GO and 25x100 Ob. The Ant 20x80 on the left has a 4.25mm exit pupil. The GO 20x80 center has a 3.85mm exit pupil. The Ob 25x100 at right is 4mm.

The Garrett 20x80 has a slightly smaller exit pupil than the Oberwerk 25x100. With the two binoculars placed side-by-side, the difference is obvious visually. I did not see an aperture stop in the GO 20x80. It is possible the prism shelf opening is reducing the aperture. Or it is possible the true magnification is not 20x but closer to 21x (20.8x).

If the GO has an aperture stop somewhere in the light path, then the effective aperture is 77mm and light gathering is 93% of expected. If it is not an aperture stop but the eyepieces are resulting in magnification of 20.8x, light gathering is fully based on 80mm, but brightness of the exit pupil would be 93% of anticipated and magnification is about 4% greater than stated. I cannot test which it may be with any precision. However, in attempts to check magnification, it appears it may be more than 20x.

The Garrett Optical 20x80 has an exposed prism edge showing in the front facing prism. It can be seen causing minor prism light cutoff in the exit pupil. The prism chord is estimated at 1/5 prism hole diameter. The area outside the chord results in a very minor 2% light loss. I have seen prism light cutoff in a number of binoculars, sometimes as much as 4% to 7%.

You often hear discussion about exit pupils, maximum exit pupil for your eyes and using higher magnification/smaller exit pupil to improve dark sky background. So here are a few comments on those several subjects.

If a binocular has a larger exit pupil than your dilated eye pupil then you do not get to use all the light from the entire aperture. Your smaller eye pupil would create an effective aperture smaller than the whole aperture. For example, let's say you decide to use the 25x100 in daylight. Let's say in daylight you eye pupil only dilates to 3mm. A full 100mm aperture at 25x produces a 4mm exit pupil. But your eye will only let in 3mm of the light. Therefore the effective aperture would be 25x3mm = 75mm. It is not likely during night use anyone would be losing light from any of these giant binoculars, but it is probable that nearly everyone would lose light and aperture if these binoculars were used in daylight.

Can you improve the view in bright skies by using a smaller exit pupil? Well, yes and no. Since point sources do not have apparent size and therefore do not have surface brightness, the light from point sources remains constant. But the sky background has apparent size, acts like an extended object and hence does have surface brightness. If you keep aperture constant and increase magnification (and therefore decrease exit pupil) the sky background will appear darker. Since the stars do not change, faint stars (point sources) will then be seen easier against the darker sky background.

But how about extended objects? Once again, if you keep aperture constant and increase magnification (and therefore decrease exit pupil) the sky background will appear darker. But so will every other extended object, and by an equal amount. That includes any faint object that is not a star. So it will NOT be any easier to see extended objects against the darker sky background because the extended object will appear darker by the same amount the background darkened.

OK, how do you improve your chances of seeing faint extended objects? Well if you keep magnification constant and increase aperture, exit pupil will get larger and very likely a bright sky would generate a more washed out image. But, if you keep exit pupil constant and increase both magnification and aperture, you will increase the amount of light gathered and you will increase your potential for contrast detection. This is the old tried and true "Aperture Rules" formula, except that you pay attention to what size exit pupil works under your bright skies. Even though both have an equally bright 4mm exit pupil, a 25x100 will see faint extended objects easier than a 20x80.

So it depends on what you are looking for. If you are observing for clusters, you can improve apparent contrast against a bright sky by simply increasing magnification and decreasing the exit pupil. If you are searching for faint extended objects, the only way to improve contrast detection is to use more aperture.

Field of View – TFOV - AFOV

I have not found the need to use any sort of finder on any binocular with a field of view down to about 2°. Viewing thru the binoculars seems easier to me than viewing thru a finder. FOV is not as much an issue for me when I jump to higher powered binocular viewing in the 20x to 25x range. The Tfov gets smaller, but the image scale gets a lot bigger and objects are easier to see. Since I don't seem to have much problem finding things, maybe that's what makes it a non-issue for me.

Oberwerk 25x100 IF is specified as 2.5°. It measures 2.35°. Afov = 58°.
M44 easily fits in the fov.

Celestron 25x100 Skymaster is specified as 3.0°. It measures 2.45°. Afov = 61°.

Garrett Optical 20x80 Gemini is specified as 3.15°. It measures 2.9°. Afov = 58°.
Orion's Belt can be seen.

The BT100 straight-thru binocular is f/6.2. It comes standard with two sets of WA eyepieces, a 24.5mm = 2.5° Tfov at 25x and a 10mm = 1° Tfov at 62x. Both eyepieces have an apparent fov of 62°. I use various plossl eyepieces that give a somewhat narrower field of view, but a much more highly corrected field of view (my personal preference) compared to typical wide-field eyepieces. Among my eyepiece pairs are:
26mm TV plossls give 24x with a 2.2° Tfov. Afov = 52°.
20mm TV plossls give 31x with a 1.6° Tfov. Afov = 50°.
14mm TV Radians give 44x with a 1.35° Tfov. Afov = 60°.
All of these Tfovs have been measured in the field to within a few percent of expected.

Unlike some other interchangeable eyepiece binoculars, the Oberwerk BT100 does not have any internal field stop between the eyepiece holder and the prism. Therefore, the eyepiece field stop, nominally the Afov of the eyepiece, determines the field of view in the BT100. That would not be the case for instance in the Miyauchi Saturn which do have an internal field stop which limits fov.

Some other binoculars for comparison are:
Oberwerk 15x70 is specified as 4.3°. It measures 4.3°
Fujinon 16x70 FMT-SX is specified as 4.0° and measures 4.05°
Oberwerk 20x80 Standard is specified as 3.5°. It measures 3.2°.

FOV Object Size
Some few objects are so huge that they will not fit into the small field of view of these high powered binoculars. The Hyades is too large. You can't see all three belt stars of Orion at once in a 25x100, but you can in a 20x80. Even the Pleiades is just a little too large to be viewed in context with a 25x100, but the amazing depth provided by the 25x100 binocs allows seeing about 200 stars in this cluster. Using the BT100 with a pair of 12.5mm UO orthos (50x), the Christmas Tree cluster nearly fills the entire fov (it's only about 0.9°).

Inter-Pupilary Distance & Eye Relief
The Oberwerk 25x100 has an inter-pupilary distance (IPD) range from 61mm to 71mm. That is really quite a narrow range. Although it should accommodate most users, this closest limit of 61mm means this binocular may not work for any users with an IPD that measures only in the 50s. That would be almost all young children, many of whom I have found have IPD of 55mm to 58mm.

Oberwerk 25x100 eye relief is substantial and easily allowed me to view the entire field from edge to edge while viewing with my glasses and the eyecups folded down. I measured 18mm, with a 3mm recess to the lens leaving 15mm usable eye relief.

The Celestron 25x100 has an inter-pupilary distance (IPD) range from 56.5mm to 74mm. That's quite a wide range. Not too many binoculars get down smaller than 57mm.

Celestron 25x100 eye relief is measured at 15mm, but there is a 6mm recess to the lens, so effective usable eye relief is only 9mm. That's very short. When used with my glasses on, I have to look around a little to see the very edges of the field. This deeply recessed eye lens is very similar to that found on the Fujinon 16x70, one that also requires I look around to see the entire field of view inside. With these two binoculars, looking straight into the eyepiece while wearing glasses cuts off about 10% of the field of view. That could be considered substantial for an eyeglass wearer. Considering the Tfov is only 2.45°, the net field of view due to short eye relief is only about 2.2°. Tilting the head slightly allows seeing out to either edge of the field.

The Garrett Optical 20x80 Gemini has an inter-pupilary distance (IPD) range from 61mm to 71mm, exactly the same as the Oberwerk 25x100. That's not surprising since the GO 20x80 Gemini has the same prism housing as the Oberwerk. The Oberwerk Mariner 10x60, the Oberwerk 25x100 IF and the Garrett 20x80 Gemini have the exact same prism housing construction. Remove the barrels and cover the nameplate and you would not be able to tell one from the other. The same comments made about the Oberwerk 25x100 must be made about this binocular. Although it should accommodate most users, this closest limit of 61mm means this binocular may not be the right choice for any users with an IPD that measures less than 61mm.

GO 20x80 eye relief is measured at 18mm. With the eyecups folded down, recess depth to the eye lens is 5mm, so the effective usable eye relief is about 13.5mm. I could not quite see the field stop all the way around all at once with my glasses on, but I was only losing a very small fraction. With the eyecups fully extended, and without my glasses, I needed to scrunch in tight to see the entire field of view.

The BT100 has an inter-pupilary distance (IPD) range from 58mm to 80mm. It's possible some very wide eyepieces might hit together when used for a narrow IPD. However the supplied WA eyepieces are pretty large, 50mm in diameter, and these do not come in contact even at the narrowest setting. For my IPD setting of 62mm, the supplied eyepieces have a 12mm space between them at the narrowest point.

The BT100 eye relief is dependant on the eyepieces you select to use for your viewing. It uses any 1.25" format eyepieces. The 62x WA eyepieces supplied have enough eye relief to use with glasses but in the low powered 25x eyepieces there is very slight field cutoff. The Meade 26mm SP LP has a deeply recessed lens, so there is a bit of the field of view lost when wearing eye glasses. The TV 26mm plossl eyelens is right at the surface and more prone to eyelash dirt but with glasses has no loss of field.

Baffles and Blackening
Control of stray light is important to keep contrast. There will be stray light inside any instrument. If it reflects off of any shiny surface, it will potentially cause ghosting and reduce contrast. All of these binoculars have the internal surface of the objective barrels sprayed with a dull black of dark gray material to subdue reflections from stray light. In the Oberwerk and the Garrett it can easily be seen that the surface coating is not particularly evenly applied. It is not dark black. But at least the entire surface is covered such that there are no shiny surfaces exposed.

In the BT100, the entire interior surface is well coated with a roughened black coating. Also, there are four baffles between the aperture and the prism. It appears the first baffle may also be acting as an aperture stop, reducing aperture by just a few mm.

I did not see any baffles in any of these other binoculars.

Lens Caps
I must be old school. I like lens caps that slip on over the objective barrels. The Oberwerk 25x100 and Garrett 20x80 objective lens caps are rubber and they stick into the barrel. They are a real pain to get to stay in. Not to mention, when the lens caps are cold, they shrink and they no longer fit. They fall off as if they were sized for a binocular a few mm smaller. This is a deficient design. However, I do like the one piece hinged

eyelens caps. They fit very well whether the eye cups are up or down and you are far less likely to lose an eye cap since it is a pretty big piece.

The BT100 objective lens cap is a solid one-piece hard plastic insert. It fits the entire body housing. It easier to get in/out than the soft rubber inserts mentioned above. The BT100 stock eyepieces do not come with any caps. I purchased field lens and eye lens caps from Orion for about $3 each. That's 8 caps, so about $25 to put caps on eyepieces that in my opinion should be furnished with caps. When the eyepieces are not in the BT100, the eye end openings have a screw on metal cap.

Hinges
The BT100 is a solid body binocular. Only the prism housing moves to adjust IPD. It is fairly easy to grasp the entire prism housing and adjust the IPD. It will not move without a fair amount of force so there is no chance of knocking it out of your IPD setting.

The Oberwerk, Celestron and Garrett are all substantial sized binoculars with a fairly robust hinge and a front objective support hinge. It takes a fair amount of force to change the IPD setting. These are easily adjust in the field if being used by several individuals all of varying IPD setting. I've heard some people complain that the supporting rod where it attaches to the prism housing is not rigidly stationary. I would only be concerned it this attachment were loose to the point of causing a lack of support. This can be tightened at the support bar shaft sleeve near the prism housing.

Optical and Mechanical Deficiencies
I had some problems with the Celestron 25x100, that the left eyepiece would not achieve a pinpoint star focus, overall the view was pretty good, but the finest point star image thru the left eye was a noticeably enlarged round blob, not a fine point. This indicates some problem. Had these been a purchase, I would have sent them back as defective.

On both the Oberwerk 25x100 and the Celestron 25x100 the center mounting post was simply too short. I could not mount either of these binoculars on any tripod without the bottom of the barrels rubbing against the top of the tripod mount plate. If I were a person with a very narrow inter-pupilary distance, I would not have been able to achieve anything less than about 60mm with the currently supplied mounting post. There is no way to take that post off the binocular and replace it.

The Celestron 25x100 showed some slight ghost images on bright objects. This would indicate there are some internal reflections. This is consistent with surfaces that are not FMC.

The Garrett Optical 20x80 has an exposed prism edge resulting in minor prism light cutoff. Also the GO 20x80 shows an exit pupil size inconsistent with 20x80. It may be higher magnification or there may be an internal aperture stop.

This BT100 had a bit of astigmatism in one barrel. It was more pronounced with some eyepieces than with others. It was very difficult to focus the image in this barrel to get as fine a pinpoint to match the nice image in the other barrel. The out-of-focus diffraction image in the affected barrel is decidedly oblong horizontally one side of focus and vertically the other side of focus. A small cross appears at the point of image focus. It appears to be less noticeable at lower magnification, I assume simply because the image is smaller. I used a Cheshire eyepiece to correct most of the alignment. The condition is now much better.

Collimation

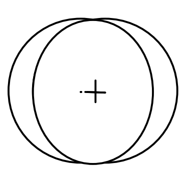
The Celestron 25x100 was out of collimation by 1 arc minute. That doesn't seem like much but at 25x, some may find it annoying. Most of the time I don't see it, but I had a difficult time focusing on Jupiter and I thought this might be part of the problem. I made no attempt to realign this binocular. The Celestron does not have readily accessible adjustment screws. They are very likely right under the coating, but that means cutting or poking thru it to get at the screws. I decided not to.

The G.O. 20x80 Gemini has the same prism housing as the robust Oberwerk Mariner line. The Oberwerk Mariner 10x60, the Oberwerk 25x100 IF and the Garrett Gemini 20x80 have the exact same prism housing construction. If you were to remove the barrels and cover the nameplate you would not be able to tell one from the other. My G.O. 20x80 arrived with point source images well collimated to within 30 arcseconds. Field of view overlap is nearly matched.

To get an idea of the comparative difference in collimation error as viewed by your eye, the 25x Celestron at nearly 1 arcminute error has an apparent error of 25 arcminutes. The 20x Garrettt at only _ arcminute has an apparent error of only 10 arcminutes. The BT100 at 40 arcseconds error before correction had an apparent error of 17 arcminutes at 25x, but it had an apparent error of 41 arcminutes at 62x. After correction, I estimate the apparent error is now 6-8 arcminutes at 25x and 15-20 arcminutes at 62x. At 44x with a 14mm Radian, that would be an apparent error of 11-15 arcminutes and it is not noticed.

Misalignment of the Field of View

The Oberwerk 25x100 arrived with point collimation dead on, but there was a difference in barrel field of view overlap. Imagine looking thru the eyepieces of the binocular and what you see is two circles but they don't overlap perfectly. Best way I could describe it is this. If I were to fix the binocular field of view on a yard stick at some distance away, in one barrel I would see from the 5" mark to the 30" mark. In the other barrel I would see from the 7" mark to the 32" mark. This exaggerated image here should help.



The field of view in the Oberwerk 25x100 is about 2.35° or about 140 arcminutes. In the binocular I received, the overlap was off by about 8 - 10 arcminutes, or by about 7% of the field. However, stars were merged almost dead on. You would say these binoculars were collimated on point sources. So what was the problem?

This is what I think. There are four prism tilt screws on a binocular, one for each prism. I think the images in this binocular originally were not merged and the wrong screws, the eye prism screws, were adjusted to merge point sources. If the objective prism was tilted from the light path, but the eye prism was adjusted to merge the out-of-line images, then afterwards that barrel would show a different field of view than the other barrel.

What I did by trial and error was throw the merged images out of line little by little by turning the eye prism screw and then realigned the field little by little using the objective prism screws. Once I got the field to match in both barrels, I needed just a slight readjustment of the eye prism screws to make a fine adjustment to merge the images. Just to raise a few questions: How many of you have ever used a little jeweler's screw driver to adjust the prism screws on your binoculars? Did you access the eye prism screws or the objective prism screws? How do you know if you adjusted the prism that was tilted in the first place?

I've seen one set of instructions for collimating that don't even show the access holes for the objective prisms. So I'm guessing that it is most likely the screws accessed to adjust prisms most often are the eye prism screws. Just one more question for thought. What do you think is the likelihood that it is always the eye prism that needs adjustment and the objective prisms don't?

I'm happy now with my Oberwerk 25x100. I now have near perfectly matched field of view AND merged point source images.

A Floating Prism Shelf

The Oberwerk BT100 prism housings hold what are described as massive prisms. There are three separate cover plates over openings into the prism housings. These tiny cover-plates must be removed to access and make adjustments to the prisms if necessary. This is not like the common binocular with prism tilt screws. Collimation is quite different, very precise, rugged and well designed. The massive prisms are mounted to plates that float on three points, each point finely adjustable.

Inside the prism housing are three little wheels. Whereas on a closed binocular you find little screws outside the prism housing, these wheels perform the same function. The wheels look like little tinker toy sprockets, if you can remember what those are. As you rotate a wheel about the axle, it raises or lowers that side of the prism plate. I believe it is best to adjust these exactly like you would perform collimation on a three screw SCT secondary mirror. You never make all of the adjustment with one screw. If you need to raise one screw you also equally lower the two screws on the opposite side of the prism plate. So adjustments need to be made in baby steps.

I measured point source image separation between the objectives originally at approximately 40 arcseconds separation. How could I measure it that fine? I observed a 62 arcsecond double star Nu Draco to test collimation on point sources. I could easily watch as both components tried to merge. I could see the error in mis-alignment was about 2/3rds of the space between the components of this double star. Normally separation is measured in several arcminutes, but at high magnification even a small amount of mis-alignment can cause headaches. I have made minor adjustment to reduce this error and have seen a noted improvement.

Collimating the BT100 with a Chesire
About 2-3 months ago, I spent some careful time testing both barrels on my BT with a cheshire collimating eyepiece. This is a great tool for checking the alignment of a refractor. This is how you would test a refractor with an adjustable lens cell. When you shine a light into the side of the cheshire, you can see a circular image in the capped objective lens. If the objective is slightly tilted off the optical axis, you will see two circles. The tilt might be only a fraction of a mm. To correct the image, the objective must be adjusted until the two circles overlap to make one.

Knowing that I had a 40 arcseconds of mis-collimation, and finding the right barrel objective slightly out of alignment, using the Cheshire I made some small conditional adjustments to the right side prism shelf. Although I was not able to completely correct the mis-alignment in the right objective, I did nearly fully correct the conditional misalignment of the two barrels. My BT operates somewhat better with the stock 62x eyepieces than it did before. The residual misalignment of the objective in the right barrel causes minor astigmatism in the right barrel image. This is typical of a refractor with a slightly tilted objective lens.

Therefore, it is relevant to note that high powered images in these large dual refractors can be affected by either mis-collimation of one barrel to the other, which we all know as being corrected by conditional alignment, or it can be affected by slight misalignment of the objective lens. In this case I have achieved conditional alignment, but cannot remove the residual astigmatism. That astigmatism causes image breakdown at higher powers. It is now only just acceptable at 62x. It is not bad at all at 50x. It is not noticed at 44x. If I decide that I want to begin using this instrument at even higher powers, I may make a further attempt at correct this little problem even more. I have only ever made this one change to the prisms. Nothing else has ever moved in these binoculars.

COATINGS

Antireflection Coatings
An uncoated lens surface can reflect 4% of the light hitting it. MgF single coating can reduce that reflection to 1.5%. Properly applied multi-coatings can reduce that reflectance even further to 0.5% or 0.25% per lens surface. Furthermore, improperly applied multi-coatings may do no better than or not even as good as good single coatings. A binocular may have as many as 14 lens surfaces. Even a properly multi-coated binocular can transmit at best only about 93% to 96% of incoming light. The same binocular with 14 surfaces if MgF single coated may transmit only 79% of the light.

Reflected Light Shows Light Not Passing Thru the Lens

Not all anti-reflection coatings are created equal. An indicator of the quality of antireflection coatings may be reflections you can see when looking into them. Any reflection you see in the coatings is light reflected off the lens and not passing thru the lens. Step outside under full daylight and let the sunlight shine on your face. Use the objective lens like you would a mirror and look for your reflection in the coating. The desired result is the least amount of light reflected off the coated surfaces. That means the most light is getting through. It is difficult to see any reflections at all in Fujinon or Nikon SE coatings. Look at your reflection in a binocular with lesser quality coatings and you will be able to see your full reflection in color with detail in your face.

Look into the objectives of an Oberwerk BT100 binocular telescope and you will barely see the outline of your head. You will not see any detail in your face. The BT100 has a nice even coating with a green/purple tinge. The Oberwerk BT100 reflects less light than either the Oberwerk 20x80 standards or the Oberwerk 15x70. The Fujinon 16x70 reflects just a bit less than all of the above.

The Oberwerk 25x100 has fully multi coated optics on all surfaces. The coatings reflect very little light. No internal reflections were noticed.

The Garrett Optical 20x80 Gemini has fully multi coated optics on all surfaces. The coatings reflect little light.

The Celestron Skymaster 25x100 has objective coatings that appear purple/green with little reflection off the objective lens. However, the objective prism face and the eye lens in the Celestron 25x100 shows a light blue reflection. The eye lens and prism coatings on the Celestron 25x100 appear like they might be single coated MgF.

Internal glass surfaces that are not multi-coated reflect more light back off the surface and do not permit that light to get through the lens. Not only does that reduce the amount of light that gets thru the lens, but also the light reflected internally causes contrast losses in the image. So, lower quality coatings reduce light in the exit pupil and reduce contrast. These two things can contribute to a less bright image in the exit pupil, even when compared to a binocular with equal exit pupil.

RESOLUTION

On-Axis Resolution - Double Star Observations and USAF Line Pairs Charts
Double stars provide a good measure of binocular resolution. Of course, binoculars won't allow reaching the resolution limits of the aperture due to the low magnification, so it's as much a measure of your own acuity, the ability of your eyes to separate close objects. But, if the same observer performs the same type of observation thru all the instruments then you have a relative measurement. It may vary slightly from someone else with a different acuity, but they would get similar relative measurements of resolution with the same group of instruments.

Some binoculars focus to a finer pinpoint than others. And obviously, magnification provides a greater ability to split closer doubles. Generally, binoculars with higher magnification allow seeing closer doubles, but sometimes when comparing binoculars with very close magnification, such as 8x vs 8.5x or 15x vs 16x, the binocular with a finer image may exceed the limits of one with a higher magnification. What this also means is you get to see a lot more resolution in dense clusters because binoculars with the ability to see that closer double will separate more stars in a cluster. This allows you to define that word resolved.

On-axis resolution can also be measured with USAF Resolution Charts. The results you will get using line pair charts in daylight will far exceed the resolution you can see on stars at night. I've tested and recorded resolution on stars for every binocular I own and I've tested about two dozen of those binoculars on USAF line pair charts. Almost every one of those binoculars can resolve line pairs in daylight about 40% closer than what can be seen when splitting stars.

For example, I can see about 150 arcseconds apparent separation clean splits of equal magnitude stars. With the same binoculars I can clearly see line pairs resolved down to 90 arcseconds. (150-90)/150 = 40% closer separation on line pairs. This is consistent across almost all binoculars I have tested, within a few percent.

Line pair chart resolution is a good indicator of contrast transfer. The resolution is measured center to center of two thin black lines separated by an equal width white space. Lines are exactly 5x longer than they are thick. Lines are much easier to see resolved than point sources. But seeing equal spaced black lines and white spaces requires a high contrast transfer in the instrument. When you reach the point where you can no longer see lines, but can only see gray, you reached the limit of contrast transfer.

When the results of these tests are provided in terms of Apparent Separation or Apparent Resolution, you can then compare one binocular to any another with much different magnification. For instance, I have several different binoculars that can see 150 to 160 arcseconds apparent separation on point sources. Using 150 arcseconds apparent for the example, that would mean I have observed a 15" double in a 10x binocular, a 12.5" double in a 12x binocular, a 10" double in a 15x binocular and a 7.5" double in a 20x binocular. Using the line pairs chart all of these binoculars can see from 87 arcseconds to

97 arcseconds apparent. Using 90 for the example that would mean I have observed line pairs giving resolution readings of 9arcsec, 7.5arcsec, 6arcsec and 4.5arcsec respectively.

Some resolution tests for binoculars are published based on using supplemental magnification, a small magnifying scope behind the eyepieces, to test for the maximum resolution that can be seen thru the instrument under high magnification. Some other resolution tests are based on a single line width rather than line pairs. Line pairs correlates to the Contrast Transfer Function, not resolution of a single line. In fact a thorough reading of several highly regarded texts on resolution will tell you that single line resolution can be noticed sometimes even at only 20% of normal point source resolution.

The most important point here is this; when reading resolution results provided for various instruments you must also have a clear definition of how the resolution readings were obtained. Readings can vary considerably from one form to another. Resolution readings of any instrument, from easiest to most difficult in order of increasing separation, for instance with a 20x80 binocular, might show approximate resolution values of Single Line width 2.25 arcseconds, Supplemental Magnification 2.25", Line Pairs 4.5" and Point Sources 7.5".

Point Source Resolution in Apparent Arcseconds
Gamma Del, the point star of Delphinus, at 4.5-5.5/9.6"is a double I look at almost every time it's out. This is too close for a 15x or smaller binocular. In the G.O. 20x80 it was clearly separated. A little below y Del is a much tighter double, Stf2725, at 7.6-8.4/5.8", a challenge even for a 25x binocular. I noticed the 5.8" pair elongated in the G.O. 20x80.

In Oberwerk 25x100, y Delphinus was seen separated pretty easily. It's 9.6 arcseconds. Struve 2725 appeared elongated and pointed nearly towards y Del, estimated PA 330 to 340. Stf 2725 is 5.8 arcseconds and gives 145 arcseconds apparent, just below my limit of resolvability.

Gamma Aries, known as Mesartim, is sometimes called the perfect double. The two stars are both mag 4.8 with a 7.8" separation and the position angle is exactly North-South. The separation can be a bugger for a 20x binocular, but with the GO 20x80s on this night it appeared clearly separated three different times. In the 10x60, elongation is not even noticed. Mesartim cannot be seen split in a 15x binocular.

The Celestron 25x100 do not reach a perfect pinpoint focus on one side and that hampered the view of Mesartim 7.8" somewhat. I was easily able to see the two components, but they were not clearly separated. The position angle was evident and there were two distinct bright components, but I could not see any solid space between them. I would say they were deeply notched. That is an apparent separation of 7.8x25= 195 arcseconds. The Celestrons should have been able to cleanly split this easily. Finally on another night they did. Maybe the first time I could have spent more effort on critical focusing.

On other nights with the Celestron 25x100s, the Trapezium, with closest components at 8.7”, gave none of the difficulty associated with 20x80s. I clearly separated the double Struve 953 in Mon at 7.2-7.7/7.1”, just below the Christmas Tree cluster. I split this one "easily" in the BT100. I've seen it elongated but not split with the 20x80 Oberwerk Standards.

In the Oberwerk 25x100 I could see 23 Cancer was a double, but I could not see the components separated. 23 Cnc is only 5.1" wide. I've never split a double that close at 25x. I even tried 16 Cnc and while it was seen to be double at 6.0" it was not split. That also would have been better than I've ever done at 25x, but just at the limit. I did cleanly split Struve 953 in Monoceros, just below the Christmas Tree cluster. It's 7.1" and mag 7. One night I saw 95 Herc at 6.3” cleanly split several times.

With Oberwerk BT100s, along with Mesartim at 7.8”, other successfully split doubles were Struve 953 Mon 7.2-7.7/7.1” at 24x = 170 arcseconds, Struve 232 Tri 8.0-8.0/6.6” at 31x for 204 arcseconds, and 95 Herc 5.0-5.1/6.3” at 25x = 158 arcseconds. I have no eyepiece combinations for the BT between 31x and 25x.

In the BT100, at 25x, I saw 75 Herc, 4.6-5.6/4.1” elongated suspected duplicity. At 36x, the elongation was positive and I suspected seeing a notch between the two components. I estimate the PA at 300°-310°. Later I found actual PA is 316°. With a 14mm Radian at 44x, I was able to cleanly split 75 Herc.

In the BT100 at 50x, Struve 1177 in Cancer (RA 8h05m Dec +27d30m) 6.6-7.5/3.5" was split. I could not split Castor, wider but too bright. 24 Cancer, 7.0-7.8/5.8", was split with the 20mm TV eyepieces at 31x. 23 Cnc at 6.3-6.3/5.1” was also split at 31x.

Doubles resolved in the 16x70s are more sharply defined than any other binocular, smaller or larger. But the higher powered 22x and 25x binoculars, even though some do not resolve to as fine a point, are capable of so much closer separations, they get to see closer doubles, which also means they are seeing more stars resolved in dense clusters.

With the Fujinon 16x70, on numerous occasions I have seen Gamma Delphinus 9.6” split at 16x for an apparent separation of 154 arcseconds. To date, I believe 150 arcseconds is the best clear resolution I have recorded with any binocular.

Sharpness Across the Field of View
This test is really checking the outer field of view for aberrations such as coma or spherical aberration. Not surprising, but some of the best binoculars show significantly better sharpness towards the outer edges of the field of view. The Fujinon FMT-SX 16x70, the Nikon SE 12x50, Pentax PCF WP 16x60 and the Oberwerk Standard 20x80 display excellent sharpness across the field.

A binocular with a sharper image still sees fainter stars and objects further out in the view. One with a less sharp view spreads the star images out over such a large area that it has already lost the faint stars from view by the time the sharpness has become only fair and has lost much more than just the faint stars at the point where sharpness is poor.

Sharpness Across Field					clear	on														
	Mag	Afov	Tfov	detec	elong	axis	25-35	40	45	50	55	60	65	70	75	80	85	90	95	100
Oberwerk BT100 - 26TV pl	23.8	50	2.10		157	169	186			186	170								331	
Oberwerk BT100 - 24.5 WA	25.3	64	2.53			158						185	190					735		
Oberwerk BT100 - 20TV pl	31.0	50	1.61			158	205						195			186			220	
Oberwerk BT100 - 17 OS pl	36.5	50	1.37			150	254								230					
Oberwerk BT100 - 14 Radian	44.3	60	1.35			182			195			206								226
Oberwerk 25x100 IF	25	58	2.32	126	150	158	178			183	183		335	355	450	480	550			
Celestron Skymaster 25x100	25	61	2.45			178						355		525	550	735				
Oberwerk 22x100 A	22	62	2.80			172						312		462		647				
Oberwerk 22x100 B	22	62	2.80			172			310		464	638								
Oberwerk 20x80 Standard	20	64	3.20	142	156	174						258		284		440				
Oberwerk 20x80 Deluxe	20	65	3.23			174									440					
Burgess LW 20x80	20	74	3.70		142										720					
Garrett Optical 20x80 A	20	58	2.90		120	156							266		284	440	440	720	720	1260
Garrett Optical 20x80 B	20	58	2.90		126	156	266			360	720	720								
Fujinon 16x70	16	65	4.05		118	154						227	288	307	336	352	470		576	
Nikon 12x50 SE	12	60	5.00	115		160				170			216			264	432	432		
Oberwerk Mariner 10x60	10	51	5.10		142								290				360			

Sharpness as Measured by Apparent Resolution (in arcseconds)

Checking doubles at various points along the radius allows us to determine the loss of sharpness by referring to the apparent resolution at the points measured. For this, the magnification comes into play. The separation of the double multiplied by the magnification gives apparent separation as seen at that magnification thru that binocular.

It should be noted here, the placement of the test star is measured accurately by placing a chartable field star either in the center of the fov or right on the edge of the field stop and then measuring a large scale chart distance from the test star to the chart star.

It should be easily understood even a fairly close double will get easier with higher magnification. However, a considerable degree of sharpness is still required to see close doubles split. So a higher magnification binocular must be able to split a closer double to get at same apparent resolution as a lower magnification binocular. As an example, a 12 arcsecond double in a 20x binocular would be equivalent to a 9.6 arcsecond double in a 25x binocular. Therefore, various doubles are used to test sharpness. Based on the above, the sharpness as measured by apparent resolution (in arcseconds) of various binoculars is given. When comparing one binocular to another, at any given % out from center lower is better.

With the Oberwerk 25x100, I was able to observe a 7.3 arcsecond double (11 Mon) still cleanly separated at about 50% to 60% out from center for an apparent resolution of 183 arcseconds. That's really very good central area resolution performance and at the 60% out mark exceeds the capabilities of the Celestron 25x100 by nearly a factor of 2. It also exceeds the capabilities of the Oberwerk 22x100 which at very best achieved a resolution of 310 arcseconds at 60% out. The Oberwerk 25x100 is still able to resolve doubles of 18” and 19” at 75% to 80% out from center.

In the Celestron 25x100 sharpness of image is fair at 70% out from center, but then it drops off very quickly beyond 70%. By 80% out it gets rather poor. The Celestron has a problem with one barrel of the binocular that won't allow it to reach pinpoint focus as well as the other side. The Celestron 25x100, when observing a 14" double, was very clear at 50%, still good at 60% but poor at 70%, all the way around. Doubles of 21" and 22" could still be seen at 70-75% out from center. A 29" double was the limit at 80%.

The Oberwerk BT100 at f/6.2, with 20mm TV plossls at 31x is sharp right up to the very edges of the field stop. You can put a 7" double right up to the edge of the field stop and still observe the two components cleanly separated. Why? Because it is using a well corrected TV 20mm plossl.

With the BT100, superior sharpness is seen with the TV 26mm plossl 2.0° fov and with Televue 20mm plossl 1.5° fov eyepieces. View is quite a bit narrower than the stock WA 2.5° fov eyepieces, but you can literally put objects right out to the edge of the field stop and still see a near perfect view with almost no distortion present. In the BT100 with a 26mm TV plossl at 24x, a 14" double can be put right on the edge of the field stop and still be seen as two. At 25x with the standard 24.5mm wide-angle eyepiece supplied with the BT100, a 7.4" double can be seen only out to 60-70% before it becomes distorted.

I compared Meade 26mm SP LP to Televue 26mm plossls and also to the stock Oberwerk 24.8mm WA that came with the BT100. Also I compared stock WA 25x eyepieces to Obie 25x100 IF. Both 26mm plossls are much sharper towards the edges than the stock WA eyepiece. There is very little loss of image sharpness. Stars are nice round sharp stars right up to the edge. The BT100 stock WA 25x eyepieces are equivalent to the Oberwerk 25x100 IF out to 60%. But by 80% to 90% out the 25x100IF holds up better and the stock WA eyepieces really lose sharpness of image.

Off Center Sharpness

When testing the Garrett Optical 20x80 Gemini, I found this particular sample has an off center lens sharpness problem. I reported this same anomaly when I reviewed the Oberwerk 22x100. Most binoculars have the sharp field of view centered and may provide a clear sharp field out to 60%-70% or occasionally even 80% of the field. This one is off center, sharper towards the 9 o'clock position and deteriorating rapidly towards the 3 o'clock position. Both barrels showed the same result.

A 13" double can be seen 65% out towards the left but only 35% out towards the right. An 18" double can be seen 70% out towards the left but only 40% out towards the right. A 36" double can be seen 90% out towards the left but only 50% out towards the right. Several times during the night of deep sky viewing, I would move a faint diffuse object towards the right and it would become exceedingly more difficult to see as I moved it further out of the central sharp spot in the view. It obviously had little effect on my night of observing as I captured over 60 deep sky objects in one night of viewing and some very close double stars are separated or elongated. But best view is not centered.

LIGHT GATHERING

Brightness of the image

A binocular with a larger exit pupil will have a brighter image. Well, most of the time. Often we read of a user comparing the apparent brightness of the image in the exit pupil from one model binocular to another. Assuming equal size aperture, sometimes it seems difficult to understand how binoculars with equal size exit pupil may differ in brightness or why it might be that a smaller exit pupil binocular may appear to have a brighter image. Standard calculation tells us the larger exit pupil provides a brighter image. But that is the simple calculation, and all is not always what it may simply appear to be.

Assume for example two different 100mm binoculars one with a 4.5mm exit pupil and the other with a 4mm exit pupil. Everything tells us the binocular with the 4.5mm exit pupil should give a brighter image. Why then might it be possible for the 4mm exit pupil to give a brighter image than the binocular with a 4.5mm exit pupil.

In addition to the potential light lost to the exit pupil based on the quality of the coatings and the number of uncoated or single coated surfaces, the following may also contribute to light lost from the exit pupil. Studies have shown that not all binoculars deliver all the light expected based on the simple calculations of aperture area and exit pupil. The brightness of the exit pupil is considerably affected by vignette in the binocular system, especially in the prisms. Even for some of the best binoculars, vignette is present. The amount present can cause considerable differences between models of the same sizes and between varying sizes of objectives producing the same size exit pupil. Total brightness cannot simply be assumed based on transmission figures or light gathering area and exit pupil.

If all the light that enters the front prism hole does not exit the back prism hole, it is bouncing around inside the prisms. This does several things. It causes what is known as vignette and it reduces contrast in the image. It will also reduce the brightness of the image in the exit pupil. So it is possible to have two equal sized binoculars with equal size exit pupil and yet one binocular can have a brighter image than the other. Although present even in closely sized and quality binoculars, it may not be as apparent as it sometimes is between high quality and cheap binoculars. But it is a factor.

Two measures used to help determine which binocular does a better job of delivering all the light it gathers are Limiting Magnitude or faintest point sources observable and Contrast or highest contrast images of the faintest extended objects. Neither alone truly tells the whole story of which binocular produces a brighter image, but a binocular that does both best would likely have the least amount of losses due to all of the above mentioned issues.

Limiting Magnitude

Limiting magnitude gives you an indication of how deep you will see into the many faint stars within open clusters. The deeper limiting magnitude will see more faint stars.

Studies I performed and reported previously show incremental increases in magnification have far more influence on Binocular Limiting Magnitude (BLM) gain than incremental increases in aperture. Changes to magnification or aperture (area of the lens) show each 10% increase in magnification will increase BLM by ~0.12 to 0.15 mag. and each 10% increase in area of aperture will increase BLM by ~0.03 to 0.05 mag. This shows magnification was measured to have approximately three to four times the affect on the gain in BLM. When it comes to the question "How deep can you see?" in binoculars, magnification has greater influence on performance than aperture. However, this is not an indicator of contrast or the ability to see faint extended objects. For faint extended objects, not only do you need the deepest BLM you can get, but also you need the best contrast you can get, and that is more likely associated with larger aperture.

Under my best skies ranging from mag 5.4 to 5.8;
12x50 Nikon SE see stars to a limit of mag 10.8,
16x70 Fujinon FMT-SX see stars to a limit of mag 11.0,
20x80 Garrett Optical Gemini see stars to a limit of mag 11.3,
20x80 Oberwerk Standard see stars to a limit of mag 11.2,
22x100 Oberwerk is capable of seeing stars as faint as 11.9,
25x100 Celestron could see stars to mag 12.0.
25x100 Oberwerk may have reached stars to mag 12.5.

I've observed M44 and M67 on numerous occasions now. Some nights produce better results than others, but those results generally are reflected across all the binoculars used. I observe the same field in every binocular. In M44 the stars are all spread apart and it is a measure of light gathering, Lim Mag. In M67 the stars are dense, close and difficult to pull out of the glow of the background. While it still shows the light gathering, it may also be influenced by a measure of contrast.

M44 has 80 stars brighter than mag10 and 100 stars brighter than mag 10.9. M67 has no stars brighter than mag10. M67 is more like a faint glow from which you can pick out stars as you apply more magnification. M67 has only 27 stars between mag 10 and mag 12. M67 at lower powers is nothing more than a glowing smudge in the sky, 2,500 Light years away. In the Obie25x100IF, 20+ stars can be seen resolved and the background glow of the hundreds of remaining mag 13 and mag 14 stars is bright. In stark contrast to M44, a young 600,000-year-old cluster, M67 is thought to be 10 billion years old and is a most unique open cluster for its partial resemblance of star population to a globular cluster. I recommend reading the references in Burnham's Celestial Handbook.

stars seen in M67 on different nights
6 with Fujinon 16x70
4 with Burgess 20x80 LW
14 with Garrett 20x80
18 with Oberwerk 25x100
23 with Oberwerk 25x100 best night (see M44 notable below)
20 with Oberwerk BT100x31
26 with Oberwerk BT100x44

On dark nights M44 just swarms with stars in the larger binoculars. You almost can't believe the numbers of stars seen at 25x and 30x. All the stars around M44 don't quite fit in the 1.4° field of the Radian at 44x, but the total number of stars seen is incredible. What I find really interesting is the different nature this cluster takes when viewed thru 8 to 10 different sizes of binoculars. The swarm of the Beehive takes on a whole different perspective viewed thru 25x100 binoculars. Some of the fainter members never become visible even in 20x80s. On two occasions, some of the faintest stars were just popping in and fading from view, bees coming out of the hive for just a moment.

My best views of M44 - # stars seen in M44 on different nights
90 stars using Fujinon 16x70 sky5.2
94 stars using Burgess LW 20x80 sky5.2
102 stars with Oberwerk 24xBT100 (26mm Meade SP LP)sky4.8
115 stars with Oberwerk 25x100 IF sky5.2
These observations probably reach mag 11.3 to 11.4

126 stars with Garrett 20x80 triplet IF sky5.4
127 stars with Oberwerk 25x100 IF sky5.4
125 stars with Oberwerk 25xBT100 (24.8mm stock WA ep)sky5.6
133 stars with Oberwerk 24xBT100 (26mm Televue) sky5.6
135 stars with Oberwerk 24xBT100 (26mm Meade SP LP) sky5.6
these observations probably range from mag 11.5 close to mag12

And finally these higher powered observations
135 stars with Oberwerk 31xBT100 (20mm TV plossls)sky5.0
150 stars with Oberwerk 44xBT100 (14mm Radians)sky5.2
174 stars with Oberwerk 44xBT100 (14mm Radians)sky5.5
this last observation probably reaches close to mag12.5

This one observation of M44 is singled out for notable achievement.
166 stars with Oberwerk 25x100 IF, sky 5.6-5.8
I attribute as the biggest reason for the huge gain the fact that I awoke from a nights sleep and went right outside, probably as completely dark adapted as I have been.

There is no doubt the stock WA at 2.5° provides a wider field of view. Both the Meade and the TV 26mm plossls provide approx. the same field. The Afov is about 50° and the TFOV in both is about 2.1°. Under the same sky conditions (mag 5.5-5.6) these three eyepieces were compared on M44. The stock 25x eyepiece on one night saw only 110 stars on the chart. A more recent try proved that it is capable of seeing 125 stars on the chart. This compares about equally with the Oberwerk 25x100 IF which gave two readings of 115 stars and 127 stars. Maybe the nod goes to the 25x100 IF by just a hair.

The 26mmTV plossls and the Meade 26mm SP LP plossls came up remarkably close to each other. Considerable time and effort was spent with each one to go as deep as possible. While each one saw 2 or 3 stars that where not recorded on the other's chart (that's typical), the TV saw a total of 133 stars and the Meade saw 135 stars. These are giving a magnification of 23.8x with a 4.2mm exit pupil. Precise Limiting Magnitude has not been determined, but it could be about 11.5 to 12.0.

The Oberwerk 25x100 IF performs as well as the 25x stock WA eyepiece in the BT100. Both 26mm plossls give better performance in the BT100 at 23.8x than the stock WA at 25x. And both give better performance than the 25x100 IF. I could not see that the TVs were better than the Meades, or vica versa.

Magnitude Loss in Outer Field of View

Although it does not precisely define which aberration might be responsible, greater loss of magnitude towards the outer edges is an indication of increased aberrations or vignette. Loss of image sharpness will contribute to loss of limiting magnitude. Also, magnitude loss in the outer edges of the field of view gives an indication of illumination lost to the periphery of exit pupil. A better instrument will see more towards the outer edges.

Both the Celestron and the Oberwerk 100mm binoculars lost about a half magnitude in the fov area beyond 50% out from center. In some binoculars, the loss grows to about a full magnitude or more as you move out closer towards the edge in the field of view.

The following observations are taken on a specified field of stars in M44 west area. First observation was viewed entirely within the central 50% of the field of view. Second observation is exact same field, but viewed entirely using the outer 50% of the field of view. Although exact magnitude is not given for the field, note the drop-off in the number of stars seen. This illustrates the loss of magnitude and hence faint stars in the outer area of the field of view.

15x70 Oberwerk - 20 stars seen but only 18 when viewed in outer 50%
16x70 Fujinon - 23 stars seen, but only 21 in outer 50%
20x80 Garrett – 26 stars seen, but only 19 in outer 50% right
20x80 Garrett – 26 stars seen, but only 23 in outer 50% left
25x100 Celestron - 28 stars seen, but only 23 in outer 50%
25x100 Oberwerk IF - 32 stars seen, but only 29 in outer 50%
25x100 Oberwerk BT100 - 32 stars seen, but only 28 in outer 50% (w/24.5WA Ober ep.)
24x100 Oberwerk BT100 - 33 stars seen, but only 31 in outer 50% (w/26 TV plossls)

In the BT100, using TV 26mm plossls and Meade SP LP 26mm plossls, loss of magnitude was not as great from central area to edges. Stars about mag 10.6-10.8 could be seen to drift right off the edge of view.

Binoculars like the Orion Ultraview 10x50 and Nikon Action Extremes lose approximately a full magnitude in the outer 30% edge of the view. Two other observations show a similar result and show the magnitude loss exists to some extent even in two of the finest binoculars. On same fov, same night in mag 5.4 skies;
Fujinon 16x70 sees mag 10.87 out to 50-60%, 10.64 at 80% out and 10.37 at 90% out.
Nikon SE 12x50 sees 10.64 out to 50-60% out, 10.37 at 80% out and 10.2 at 90% out.

CHROMATIC ABERRATION

Chromatic Aberration (CA) is a function of the inherent nature of a lens to focus different wavelengths of light, blue, yellow and red wavelengths, all at slightly different points along the focal length axis of the lens. By using a doublet lens, with each glass having different properties, the focus point for some of the wavelengths can be brought closer together. By using a triplet lens, the focus points of the wavelengths can be brought even closer together. CA can never be eliminated entirely.

Lateral Color Error

Keep in mind each color (wavelength) focuses to a different focal length. That means also that each color results in a very slightly different magnification. Since image scale varies with wavelength, objects off-axis show color fringes because variance in magnification causes color images off-axis to not coincide. In essence, lateral color is a form of distortion. This is why much more color is seen off-axis than on-axis.

Longitudinal Chromatic Aberration

To get a feel for the degree of the focus differential between the yellow focal length and the blue/red focal length, in a 20x80 binocular of approx 350mm focal length, if CA is well corrected to 1/2000 f, the difference in focus distance is about 0.18mm. My sample 20x80 triplet has individual focus eyepieces that have 5.5mm of travel with a rotation of 270°. Therefore a 0.18mm of focus travel is a turn of 10°. This aberration is seen as color fringe completely around a bright object when viewed on-axis.

In a well corrected doublet, the size of the blue/red CA blur can be 3x the size of the Airy disk. That is, for a 80mm lens with an Airy disk radius of 138/80 = 1.72 arcseconds, the blue/red blur may have a radius of 1.72 x 3 = 5.1 arcseconds. For faster systems (binoculars), this blur size will increase. For larger apertures, the blur size will decrease.

Focusing to a point between the yellow wavelength focal point and the blue/red focal point will gradually reduce the blue/red blur. As focus approaches the blue/red focal point, the yellow/green blur will increase in size. The smallest blur image will occur when focused midway between the two, but neither wavelength will be clearly focused. Simply moving your head from side-to-side and looking into the exit pupil at a different angle can produce a different color CA around bright objects.

Only when precisely focused on the object is CA minimized. This helps explain why binoculars when used for terrestrial viewing may show considerably more false color. Only the object at the precise focus distance will have CA minimized. Every other object in the field of view, closer than or further away than the precise focus point, may show greater CA. This may explain why a particular model terrestrial binocular with a low CA seems to have a greater depth of field. When used for astronomy, focus is on infinity and there is no depth of field to compare.

This is also why we see CA on bright objects and why it can be so difficult in binoculars to suppress CA and focus on especially large bright objects. Is this cause for alarm?

Certainly not! It is inherent in all doublet lens systems. It shows up more in shorter focal length fast systems such as binoculars. But you should understand the implications of CA in an optical system. CA has an affect on focus, light grasp and contrast.

Focus - CA makes it more difficult to reach precise focus. CA is the result of the various wavelengths in the light not reaching focus at the same precise focal length. CA has other significant effects on the image. As distance off-axis is increased, this becomes more noticeable.

Light Grasp - As CA increases, the light grasp of the instrument is reduced. CA affect on light grasp is a result on not being able to focus all the light into the Airy image. The CA light escaping to the fringes does not contribute to the overall image and this in turn affects the contrast in extended images. In a more highly corrected system, there is greater light in the image. This might explain why some observers say their apochromatic refractor reaches deeper than an achromat of equal diameter. Even though some observers might not see such a great improvement in the image from the reduction of false color, more light is being delivered to the image and the improvement is real.

Contrast – CA has an affect on contrast for two reasons. CA reduces the amount of light focused into the image, so overall contrast is reduced due to light loss. Also, in extended object images, any degree of false color CA will cause a slight color blurring at the fringes of dark detail and bright background. This will reduce the contrast needed to see such detail.

In the Oberwerk 25x100 IF no CA is seen when observing Saturn. Jupiter did show a bit of red CA, not at all objectionable, and it did not interfere at all with the detection of Io. The moon has a thin yellow band. When eyes were moved off axis the band would change to blue and purple and become thicker. Staying on axis really minimized the CA and it was no more objectionable than some other binoculars.

In the Garrett 20x80 triplets I saw no CA at all on a crescent moon. On a 3/4 moon I saw virtually the same band of CA in the Garrett 20x80 as I saw in the Oberwerk 25x100. With the moon placed right of center the outer edge was yellow green. When placed left of center the outer edge was reddish purple. Neither binocular showed CA when viewing on axis. BOTH showed considerably LESS CA than the Fujinon 16x70.

In the Celestron 25x100, Saturn produced no CA at all. No CA was seen in Venus on-axis, but blue and sometimes a purple or green was seen off-axis. Very little CA is seen on Jupiter out to about 50-60% from center. Beyond that, Jupiter produces blue CA on the inside edge and yellow/green on the outer edge. CA on the moon was green towards the outer edge.

The f/6.2 Oberwerk BT100 produced a CA free view of 5/8 phase Venus and a slight thin blue CA ring entirely around Jupiter, but only when Jupiter was about 70-80% out from center of view. Fujinon 16x70 shows blue CA around Jupiter when it is placed about 60% out from center.

CONTRAST

Think of the sky as the backdrop in a portrait. Your subject must stand out from the backdrop to be seen. Consider both the object and the background to be on a gray scale. If they share an equal shade on the gray scale you cannot see the difference between object and background. If the object is a little brighter and the background a little darker, you can see the object. Contrast allows seeing faint objects against the sky background.

The qualities of an instrument that help contribute to better contrast are several. One is the control of stray light by baffles and blackening. A premium lens that contributes the least light scatter in the image is another. Premium coatings will allow the most light to pass or improve the transmission and increase the potential for contrast detection. Coatings will also reduce internal reflected light and prevent contrast losses due to interference. And a lack of chromatic aberration will allow more light to be concentrated in the Airy image and further improve the object image for contrast detection.

Detection of Broad Extended Objects

Higher magnification reduces exit pupil and darkens the image, including the extended light of the background sky until it approaches a completely dark sky, to the point you can no longer see the field stop. Lower magnification with a larger exit pupil delivers a brighter image, not only from the object, but also from the background. Larger exit pupil can be beneficial or detrimental, depends on the sky condition. Generally, lower power makes it much more difficult to see most small subjects, but in dark sky conditions may allow you to see large broad nebulous objects. Higher power may help darken a bright sky background and may help bring out faint extended objects from the background, but also reduces the overall brightness of the image.

If you increase magnification with intentions of darkening the sky background, you reduce exit pupil and you also darken the image of the extended object. If you increase the aperture too much without increasing magnification, you increase exit pupil and you will brighten the entire image and you may get a washed out image. However, if you increase aperture AND increase magnification, maintaining the same exit pupil, you may improve the contrast detection of the faint extended object because you have gathered more light. Of course this will only work when sky is dark enough to permit the lower magnitude limit of contrast detection. If you are after open clusters, globular clusters and double stars, then magnification would be of greater benefit. But, if you are after faint extended objects with low surface brightness, then aperture may have greater benefit.

The Merope Nebula in the Pleiades Cluster

I've observed M45 with William Optics 7x50 ED, Fujinon 10x70s, Nikon SE12x50s, Oberwerk 15x70s, Fujinon 16x70s, Orion 16x80s, Garrett 20x80s, Celestron 25x100s, Oberwerk 25x100s and many others. I've looked hundreds of times with 20 or 30 different instruments. None of them, except one, showed the Merope nebula. The first time I've ever recorded seeing the Merope nebula in M45 was with an Oberwerk BT100 under transparent mag 5.8 skies using a pair of 26mm TV plossls at 24x with an exit pupil of 4.2mm. Not only does it take excellent skies and a high quality instrument, but it takes persistence! The bright portion of the Merope nebula extends southward from the star Merope, the bottom of the little cup below where the handle attaches. It is the brightest area of all the nebula surrounding M45.

The Veil Nebula and the North America Nebula

I've spent considerable time orienting to charts to find portions of the Veil nebula with the Oberwerk 25x100. I'm pretty sure I saw one bright portion dipping south from 52 Cyg. That area of the sky looked a slightly brighter gray.

Starhopping from Deneb, I easily move to the 3 star wedge that borders the western portion of the North America nebula. I have identified the star at the tip of Florida extension. Just east of there, I thought I saw brightening of the Pelican nebula. I definitely saw the brightest area, the Central America portion of the N.A. neb. The whole area of the N.A. neb. was a slightly brighter gray than the surrounding sky.

Small extended Objects M1 and M78

It has been said both M1 and M78 are visible in 10x50s. I've never tried them with 10x50s, but I'm sure it would take some pretty dark skies to see M1 and M78 in 10x50s, especially M78. M78 required searching with the Fujinon 16x70. It took me about 20 seconds to find it, even though I knew right where to look. Actually it appeared pretty bright. Unlike the graininess of the clusters, M78 appears as just a faint smudge.

M1 was much easier than M78. It was brighter and has a bright star nearby as a guidepost. It was found instantly first try. It's larger than M78, but still just a faint smudge. So I grabbed my Nikon 12x50 SE and gave it a shot. I was easily able to re-acquire M1 in the 12x50s handheld. M78 took a little more time. I needed to search around for a while, but passing over it several times showed it in the movement. Handheld in 12x50s, these two objects proved attainable.

In the BT100 at 44x I've seen M78 easily as a large diffuse glow.

Looking for M1 is like looking for a faint extended galaxy. It has none of that bright stellar glow. I missed it on my first try with the 20x80s, and I thought I knew exactly where it was. Later, I took a good look at the charts and tried again. This time, it was right there were it was supposed to be. It was pretty bright in the 20x80s.

I had to look around for a while with the GO 20x80s to see M78, but finally the small feeble light showed itself. In the Oberwerk 25x100 IF, the star hop to it nets a positive sight in a matter of seconds. It's still not a very impressive object, but there is no mistaking its presence.

Hunting for Faint Galaxies

IC 342 is probably one of the most difficult galaxies in all the sky for small instruments. It has a surface brightness of mag 15.0. I have literally been trying to see IC 342 for 5 years now and have not yet confirmed a sighting.

As a comparison M74 has a surface brightness of mag 14.4. NGC 2403 has a surface brightness of 13.9, about the same as M33 (Sb 14.0), easier than M74 and much easier than IC 342. I've only seen M74 in binoculars once in my life and that was with the Oberwerk BT100 at 24x with 26mm TCV plossls.

I recently spent a great deal of time trying to see IC342 in Camelopardalis. From the three very bright stars found at the top of Kemble's Cascade, the very faint galaxy IC 342 lies about 5° directly north. Next to the M31 galaxy group, this may be the closest galaxy to the Milky Way. I have tried dozens of times to see this faint glow and even though on this night with the Garrett 20x80 Gemini I suspected something just a little different about the spot, and I do mean the exact spot, at no time have I ever been able to say for sure that I have seen IC342. I spent a great deal of time at the eyepiece in my attempt to see IC342. Sometimes I spent several minutes without moving my eyes away at all.

I had hoped to try for IC342 again in the early morning hours after a full night sleep and after reaching much darker adaptation. But weather did not cooperate. I did try with the BT100 at 31x and 25x, the Oberwerk 25x100 and the Garrett 20x80. In each binocular, there was suspected a very faint diffuse area against the background sky. But it was never confirmed as a positive detection of the object. IC 342 has a Sb of mag 15.0 and only little brightening towards the center. It is a very difficult object to bring up to a level of contrast threshold detection. Maybe I'll get it one of these nights when I get my best skies of mag 5.6-5.8.

M101 in UMa is elusive and is not always seen with big binoculars. Unlike many other galaxies that appear with a bright center and some extension, M101 is nothing more than a faint glow covering a wide area. Often it may be necessary to tap the binocular so it wiggles a bit and that might allow you to see it. The best of nights are required. M101 has a Sb of mag 14.6 but it has some slight brightening to the core. One night, M101 was found instantly in the Celestron 25x100, it was seen equally well in the Oberwerk 22x100, but on the same night it was only suspected in the 16x70s. On two occasions recently, when awakening at 4AM and going outside completely dark adapted, M101 was found instantly with the Oberwerk 25x100. In the GO 20x80, M101 appeared as just a slight bit brighter in difference in the gray color of the sky.

M65 , M66 and the challenging companion NGC 3628 are found in Leo with M66 being the easiest, M65 difficult, and the companion NGC 3628 not seen by me in any binocular smaller than 100mm. NGC 3628 has a Sb of mag 13.5. While M66 and M65 are just seen in 15x70s, 16x70s and 20x80s, the companion NGC 3628 will not be seen. Both M65 and M66 are readily seen in the 25x100s. With the Oberwerk 25x100, 3628 was seen instantly and directly. 3628 was seen averted several times in the Celestron 25x100.

M66 to the east is the brighter and larger of the two. It appears slightly oval. M65 on some occasions is not easy to see with 70mm binoculars. One morning not only was it seen easily with the Oberwerk 25x100, but also the faint third companion galaxy NGC 3628 was seen instantly. M65 to the west has a longer narrower dimension than M66, but to me M65 is half the size of M66. On the other hand, NGC 3628, even though very faint, was seen as very long and narrow. Both M65 and M66 had a bright core. 3628 has no core at all. It's just a long faint extension. All three lie within a 1° field and make for a great view in the 25x100.

M95 / M96 / M105 galaxy group is also in Leo. These always take a little bit more time to find. Of the pair M96 / M95, many times M95, to the west, is very difficult to see. Less than 1° north of M96 is M105, also pretty bright, although smaller and rounder than M96. And right next to M105 is the even smaller NGC 3384, but it has a fairly bright core. NGC 3384 has an Sb of 12.9. 3384 is seen easily in the Oberwerk, and was also seen pretty easily in the Celestron. Only once it had been identified in the 25x100s was it seen as just more than a fuzzy starlike object in a Fujinon 16x70. M95 in Leo at Sb 13.6 was not as easy and was found easier in the Oberwerk but only suspected in the Celestron. All four of these span only about 1.5°, so they were all seen in the same field of view.

Light Grasp, Resolution and Contrast in Open Clusters and Globular Clusters
The binocular that would be best for broad diffuse extended objects may not the same binocular that would be best for most other objects. For most everything else, a higher magnification (that produces a smaller exit pupil) provides a larger image and a bit deeper limiting magnitude that allows seeing more.

M38 has stars that are spaced openly. All the stars are widely spaced but pretty faint, probably the reason why so many can't seem to find this cluster with mid-sized binocs. It has many stars easily seen, well spaced and all evenly bright, but all pretty faint with the brightest star only mag 9.5. In 20x80s, M38 is really quite spread out. So, at 20x80 it looses its appearance as a cluster with star glow. In a 10x60 you will still see a more compact cluster with a glow of stars. Too much magnification can make M38 almost disappear. M38 has a very small distant cluster nearby, NGC 1907, visible in 25x100s. It was seen easily in 20x80. On one excellent morning 1907 was seen in 16x70s. A close observer may also find a nearby planetary nebula.

M36 is much different. It is very compact, with stars tightly grouped. It's difficult to separate the stars with mid-sized binoculars. On different nights, a 15x70 saw 4 to 6 stars, the Fujinon 16x70 saw 8 and 11 stars. A glow is readily apparent because about 10-15 of the tightly packed stars are pretty bright. Both good resolution and good contrast are needed to separate them. The Garrett 20x80 saw 14-15 stars and could see the 11" double star in the center of M36. The 25x100 can see about 20 stars. M36 has 15 stars between mag 8.9 and 10.65. In the BT100 at 44x, M36 was fully resolved to 22 or 23 stars.

M37 is the most impressive of the three. It is large and very densely populated. M37 is like so many stars crowded together, there seems almost no room for all of them. It's very difficult to resolve this cluster. The stars are mostly evenly bright, but only one is very bright. Anything that can be resolved is seen across a bright, diffusely lit background. Mid-sized binoculars have a difficult time resolving the dense cluster, so even at 20x, it still holds that impression of a broad unresolved glow. But at 20x, it looked a little grainy. 25x100s can resolve maybe 40 or 50 stars, but they are so tightly packed they can't be counted. In the BT100 at 44x, it showed probably 40-50 stars resolved with a dense background glow. Using the BT100 with a pair of 12.5mm UO orthos at 50x, I could not count all the stars seen in M37.

Globular cluster M71, open cluster H20
Globular cluster M71 lies near the center of the little constellation Sagitta. M71 is faint even in a 15x70. This particular globular cluster may be one of the youngest globulars. Some even say it is either a very loose young globular or a very old distant open cluster. I see it as a difficult object to resolve in any case and GO 20x80s showed it as just a faint irregular glow. M71 was seen fainter in a 15x70 and was barely seen in the 10x60. It was fairly large in the Oberwerk 25x100, but it is not resolved. A 5" scope at 220x resolves only 10-15 stars in M71.

The open cluster Harvard 20 is less than half a degree sw of M71. A view of M71 with the Oberwerk 25x100s also shows nearby open cluster H20. I have only suspected seeing Harvard 20 in the Celestron 25x100s. It was seen in the BT100 at 37x like a faint glow around a short string of stars.

M11, M26, NGC6664 and NGC 6712
In the area just south of oc M11, oc M26 is seen easily in the 16x70 Fujinon, but neither the very faint oc NGC 6664 or the difficult small globular cluster NGC 6712 could be seen in the 16x70s. With 20x80 Oberwerk Standards, 6712 is seen as smaller and much fainter than M26 and in 6664, although very faint, 3 or 4 stars can be glimpsed.

In both the Oberwerk 22x100s and Celestron 25x100s, 6712 is seen readily and 8-10 stars can be counted directly in 6664.

In the GO 20x80, M11 appeared partially resolved. In the Oberwerk 25x100 I saw 10-20 stars resolved in M11. M26 was fairly bright. In oc 6664 I could count 9 stars and NGC 6712 was found quickly.

In the BT100 at 31x, M11 was pretty well resolved, especially with averted vision. OC 6664 shows 12 stars.

M12, M14, NGC7006
Oberwerk 22x100s and Celestron 25x100s make M12, a globular cluster, look like it is on the verge of resolution in the outer edges, where the Fujinon 16x70s could not resolve M12 at all. The Oberwerk BT100 at 36x did in fact provide some resolution in the outer edges of M12. M14 was observed with Obwerwerk 25x100 and a 15x70. It appeared twice the size and brightness when viewed in the 25x100.

NGC 7006 in Delphinus is one of the most difficult globular clusters I have observed. It was seen only if the Oberwerk 22x100 and the Oberwerk 25x100 and only after a great deal of persistence trying to see it.

MOUNTING

Mounting Considerations for 10# 100mm Binoculars (and 8# 20x80s)
These 25x100s are much larger than all 70mm binoculars and even still quite a bit larger than many of the 20x80s. These are big, real big. A 10# binocular requires a substantial mount, not just any tripod but a heavy-duty tripod with a heavy-duty head. Most light or basic parallelogram mounts groan under the weight. Many lightweight tripods are woefully inadequate to carry the load.

Celestrom 25x100 mounted on a Tiffen Magnum XL tripod with head.

You could mount a heavy 10# binocular on a lighter weight undersized tripod. It will work. But you need to consider that the supporting equipment may be overloaded, may experience weight stress problems and you may put your optical equipment at risk.

Some of the options you may need to forego with smaller mounting equipment; the fluid head ability to tilt the binocular in altitude; a lack of elevator crank center column and lack of non-rollback center column. However, if it's all you've got, it will certainly work until something appropriate can be obtained.

I use several mounts to hold these 10# binoculars. Some of the mounts I used were:
Bogen 3130 head on Bogen 3011 tripod
Bogen 501 head on Bogen 3246 tripod or Manfrotto 028B tripods
Scopestuff Cradle on Bogen 501head and Bogen 3246 tripod
UA Unimount Light on Bogen 3011 or 3246 tripods, Light & Medium Surveyor.
UA Microstar on Bogen 3246 or Medium Surveyor.

The best tripod/head combo I have used for these 100mm binoculars is a sturdy Bogen 3246 tripod with a heavy duty Bogen 501 head. That combination setup easily holds 10# 100mm binoculars steady with little shake. The 501 head has smooth fluid motions even when carrying 10# and the 3246 non-rollback elevator crank adds a level of security I think is necessary with a 10# binocular. The Manfrotto 028B is essentially the same tripod as my 3246 with the added benefit of a third section of legs, making it very tall.

A 10# Oberwerk 25x100 on Bogen 501 head on Manfrotto 028B tripod

I tried the 10# Oberwerk 25x100 on a Universal Astronomics Unimount Light parallelogram with a new heavy duty binocular bracket, mounted to a UA Medium Surveyor tripod. With only 10# of counter weight, it was necessary to extended the counterbalance rod out to far to balance the 25x100s. This caused too much shake in the image. Initial focusing was difficult because the binocular could not be made completely still with hands on. With 12.5# of counterweight, the counterweight comes in closer to the mount and the settling time was reduced to about 5-6 seconds, quite acceptable for this heavy setup. The parallelogram allowed me a lot more view from any one spot than I would typically get from tripods.

For the 7.5# GO 20x80 I used a Bogen 3246 with 501 head or a Bogen 3011 with 3130 head. The 3246/501 was as solid as a rock. The fully extended center column was stable. The 3011/3130 with fully extended center column was the least capable of all these mounts. Settling times took the longest and movement of the head was difficult. I consider this 7.5# 20x80 too much for the 3011/3130 tripod/head setup.

The 3130/3011 combination is not enough to carry the load of these big 100mm binoculars. You may significantly overstress the head/center column attachment and you will struggle with annoying image shake. I would recommend a sturdier tripod/head combo even for the 7.5# 20x80s.

Another night I mounted the 7.5# GO 20x80s to the new Unimount Light on a medium surveyor. I had 12.5# of counterweights extended about 6-8 inches to balance the binocular. Motions were effortless, and viewing zenith was easy (although not for everybody's neck muscles). The difference was noticed in the settling time. Any bumps to the eyepieces took about 6 seconds to settle. It was annoying when I was trying to capture extremely faint stars and I would bump several times. But in general, the ease of movement outweighed that extra few seconds of settling time.

The Unimount itself weighs 5#. The counterweight rod weighs 2.25#. Add 12.5# of counterweights and the mount total weighs 20#. Add to that a 10# binocular and the total load on the tripod is 30#. For heavy binocs like 25x100s that weigh near 10#, the parallelogram mount should be mounted on the sturdiest tripod you have available, in my case the Medium Surveyor.

For a 10# binocular with 12.5# of counter-weight, plus the weight of the parallelogram, it seems the Bogen 3246 is not enough tripod. For a 7.5# 20x80 with 10# of counterweight, the total parallelogram/binocular load is 25# and just under the load limit of the Bogen 3246. With the center column fully retracted, it seems to work pretty well with the 20x80s.

I tried these 10# 25x100s mounted on a ScopeStuff 2D Binocular Mount Head attached to a Bogen 501 head on a Bogen 3246 tripod. This 10# binocular demanded that all knobs on the 2D cradle be tightened very tight and still it was a challenge to keep this binocular balanced. Without the added vertical post extension between binocular and 2D cradle, the binocular could not be balanced. I felt the load was a bit too much for this equipment setup. Shakes from handling would damp after about 10 seconds but any slight touch or bump introduced minor micro-shakes that just made the observing experience frustrating.

I used the UA Microstar on a Bogen 3246 tripod to accomodate the 7.5# 20x80. The Microstar never drifted once, was not too tight in fluid movements and very capably held my 20x80s pointed straight up to any altitude including zenith without any problem. This worked very well as a combination. I find the movement of this mount smoother and far less shaky than a parallelogram. The Microstar does not provide the same viewing flexibility as a parallelogram, but it does have flexibility in mounting options. It is very compact, adds little weight to the overall load the tripod must carry and provides a little side standoff between user and tripod.

A 7.75# Garrett Optical 20x80 on a U A Microstar attached to a Bogen 3246

While the UA Microstar does very well mounted on a surveyor tripod if being used for mounting a small scope, that is not so if being used for a binocular. The changing eye height of the scope eyepiece is easily accommodated by looking down into the eyepieces. As I pointed the binoculars at different altitudes, the non-slip center column of the 3246 tripod was beneficial when it came time to need slight adjustment up or down to get the eyepieces back to the height of my eyes.

For most viewing the little bit of shake in the parallelogram settled out fast enough. For detailed observations like searching for mag12 stars at the limits of the binocular LM, the rock solid tripod provides a better platform. For moving around the sky, the Unimount Light gave the advantage.

Plan on a range of $300-$350 for a suitable tripod/head mount for 25x100s. If you are looking for a parallelogram mount, at minimum you should consider the UA Unimount Light with the heavy duty binocular bracket and a Medium load surveyor tripod. The 3211/3130 is about $150 value and may just suffice as the minimum you should consider for the 7.5# 20x80s but is not enough mount for the 10# 25x100s. The 501/3246 is about $350. This is definitely a case where you will spend as much or more for the mount than you will for the binocular. These binoculars need a sturdy mount. Don't skimp. The magnification is too much to be dealing with long settling periods. Mount them properly and under good skies you can see many deep sky objects.

The BT100 is a different animal altogether than any other 7# to 10# binocular in the 80mm to 100mm range. At 26# (12kg), it is heavier than my largest telescope, a 1200mm f8 6" refractor. You must first set out the custom tripod then attach the BT100s. The BT100 should not be picked up while mounted on its tripod, as it is very much top-heavy. You must first take the binocs off the tripod.

The standard tripod, a 16# specially modified heavy-duty wood surveyor's tripod requires the need to sit in a chair under the binocs to view at any altitude. Actually, I've found for most altitudes this can be very comfortable. Rather than invest in an alternative mount to raise or lower the BT100, I purchased a StarDust Observing chair that adjusts from about 12" to about 36". It works great.

Any consideration to use a different mount for the BT100 would require an expenditure in the range of $400-$500 just for a suitable mount. Then you would need to consider another $200-$300 for a tripod to hold the mount.

Settling times for parallelogram mounts and tripod/head combos
UA New Unimount Light on Bogen 3246
with 7.5# 20x80 damps in 6 sec max, 3-4 sec for bumps.

UA New Unimount Light on Light Surveyor
with 10# 25x100 damps in 8 sec, 5-6 sec for bumps
with 7.5# 20x80 damps in 5-6 sec max, 3-4 sec for bumps.

UA New Unimount Light on Medium Surveyor
with 10# 25x100 damps in about 5-6 sec max, 3-5 seconds for bumps.
with 7.5# 20x80 damps in 5-6 sec max, 3-4 sec for bumps.

UA Microstar deluxe on Bogen 3246
with 7.5# 20x80 damps in 2-3 sec, bumps die out quickly.

Scopestuff 2D Cradle on Bogen 501 head on Bogen 3246 tripod
with 10# 25x100 damps in 8-10 sec, 5-6 sec for bumps

BT100 on BT100 custom wood surveyor
with 26# Oberwerk BT100 damps in 1-2 sec

Orion Paragon HD-F2 w/ Paragon fluid pan head:
with 7.75# 20x80s on fully extended center shaft 73" high = 5-6 seconds.

Bogen 3011 w/3130 fluid pan head:
with 7.5# 20x80s on fully extended center shaft 75" high = 5-6 seconds.

Bogen 3246 w/501 fluid pan head:
with 10# 25x100 fully extended center shaft 75" high damps in 2-3 sec
with 8# 20x80s fully extended center shaft 75" high = 1-2 seconds.

Integral Vertical Mount Post
The Oberwerk 25x100 vertical mount post is too short. Especially when using a substantial head like the Bogen 501, that means the binocular barrels rest on top of the tripod head and there is limited range to slide the vertical post for balancing. When pointed up, it didn't seem to pose any problem. While the slide rod is probably 10" long, once that vertical post is attached to the top of the tripod, you can only use about 5" of that full slide rod length. I think a taller vertical post, similar to the post on the older 20x80 Deluxe, is a necessity for these giant binoculars.

I added a 1" extension post obtained from ScopeStuff. It solves the problem very nicely. With the 1" post added, this binocular mounted on a Bogen 501 head clears the head platform and allows full use of the slide bar and a full range of IPD adjustment regardless of where the binocular is balanced on the slide bar.

The GO 20x80 has the same mount post as the Oberwerk 25x100. However, since the 20x80 barrels are a little smaller, it has a little more range of movement. The 20x80 binoculars can be mounted with the post slid half way forward on the center rod.

The Celestron 25x100 vertical mount post is too short and has the same problems outlined above. Also it is a polished chrome bar with no base plate. I found it difficult to keep it tightened against tripod mounting plates. In addition, because it has such a narrow base, it acts like a punch and it deforms the rubber on the tripod mount plate. It is poorly designed to carry the load intended. The bottom of the vertical mount post should have a wider base plate and it should not be polished which contributes to slip.

The BT100 tripod mount assembly is permanently attached to the binocular. It has an integral locking slow motion altitude dial which when unlocked allows you to tilt the BT100 in altitude with a little effort. If unlocked, they will not move on their own but the slow motion dial will not engage. The dial provides a range of several degrees of slow motion altitude movement. I found this extremely useful when I was conducting critical observations recently in the M45 area at 50x. The modified tripod head has an azimuth lock. This is best locked when viewing to prevent fairly easy swivel. It can be adjusted to provide tension preventing slight swivel.

SUMMARY

Just to summarize some of the most relevant data in one place, I've reached these conclusions about the binoculars included in this report.

Garrett Optical 20x80 Gemini
A triplet binocular in a well constructed housing. Gets high marks for collimation, coatings, illumination, mounting, hard storage case and price. Fair marks for eye relief, pinpoint focus, diopter, fov, resolution on-axis, contrast and limited CA. Lower marks for uneven sharpness across the field of view (lens aberration), limited low end IPD, and exit pupil. A very attractive performer without the excessive bulk.

Celestron 25x100 Skymaster
A doublet binocular in a lower quality constructed housing. Gets high marks for IPD range, illumination and (current) price. Fair marks for collimation, diopter, fov and limited CA. Lower marks for pinpoint focus (lens aberration), eye relief, coatings, resolution on-axis, outer field sharpness, contrast, mounting post and nylon case. Currently the least expensive of these binoculars.

Oberwerk Giant 25x100 IF
A doublet binocular in a well constructed housing. Gets high marks for eye relief, coatings, pinpoint focus, resolution on-axis, illumination, sharpness across the field of view, contrast and hard storage case. Fair marks for fov, exit pupil, limited CA and price. Lower marks for diopter, limited low end IPD, collimation (mismatched fov) and mounting post. Still, I saw more than I ever thought could be seen in a 25x fixed power binocular.

Oberwerk BT100 Binocular Telescope
A semi-apochromatic triplet binocular in a very well constructed housing. Gets high marks for interchangeable eyepieces (eye relief & fov), seemingly unlimited diopter, coatings, resolution on-axis, illumination, sharpness across the field of view, limited CA, contrast and supplied mount. Fair marks for eye relief with supplied eyepieces, pinpoint focus and collimation. Lower marks for limited low end IPD, minor astigmatism (lens aberration), size (mounting options) and price. One of the finest instruments I've ever observed with.

Best of the bunch easily the Oberwerk BT100
Best of the fixed power binoculars the Oberwerk 25x100 IF
Best price/performance ratio Garrett Optical 20x80 Gemini

Easiest to step outside with on short notice Garrett Optical 20x80

When nothing else can see that faint extended object you've been trying to see, put a pair of 26mm Televue plossls in the BT100 for 24x @ 2.2° fov with 4.2mm exit pupil.

Credits
Celestron 25x100 photos by Mike Gilmer.

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